POWER

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Real Trouble

By RUFUS T. STROHM

Now and then my power journal
  Prints a letter from a chap
Telling tales of woes infernal
  That infest his local map;
How his boiler fails to bubble,
  How his engine's acting mean.
Say, he isn't hep to trouble
Till he runs an ice machine!

There is leakage past the packing
  On compressor and on pump,
Or the ice develops cracking
  As it slithers from the dump,
Or the blocks have cores of yellow;
  Pink, or reddish brown, or green;
These are things that vex a fellow
  When he runs an ice machine.

Quite without apparent reason
  The machine will buck and stall,
And throughout the hottest season
  The capacity will fall;
And you hunt and test and worry
  Till you're crazy in the bean.
Life is mighty swift and merry
  If you run an ice machine.

Something strikes the old receiver
  And it suddenly goes dry;
The condenser gets a fever
  And the pressure seeks the sky;
Every hour brings distractions
  To disturb the calm routine,
Since, for diabolic actions,
  Nothing beats the ice machine!

New Power Plant of Central Products Co.

By THOMAS WILSON

A modern and efficiently operated power plant distributing to a group of large shop buildings, high- and low-pressure steam, compressed air and purchased current. Features: Coal and ash-handling, a water softening unit, electrical power distribution and a full complement of instruments to give complete operating and cost data.

IN DETROIT the Central Products Co., a division of the General Motors Co., consists of several individual companies engaged in the manufacture of automobile parts. The site covers an area of over 80 acres on which there are about ten manufacturing and office buildings.

Formerly, the forge plant was equipped with four 4,000-sq.ft. boilers and the motor plant had three boilers each containing 3,000 sq.ft. of surface. As the needs of the new gear and axle shops could not be taken care of by the existing power plants, which were only two years old at the time, a study was made to determine the best plan of supplying the steam, light, power and compressed-air requirements to the group of buildings, with the result that the existing equipment was installed elsewhere and the decision made to install a new central plant to supply the various services mentioned.

Compressed air is supplied at 100 lb. pressure to the various shops by synchronous-motor-driven and steam-driven compressors. As the size of the forge plant had been doubled and now contains forty-one hammers ranging from 1,500 to 12,000 lb., it was considered that enough exhaust steam would be available to heat the several manufacturing buildings, either built or projected. Much of the exhaust steam from non-condensing generating units could not be utilized, owing to the supply of steam available for heating from the forge plant, and a considerable additional investment in condensing equipment, and a cooling tower or spray pond would be required for condensing turbines if electrical energy were generated. Consequently, owing to the low rate obtainable, electric current has been purchased, although some consideration is being given to the installation of a low-pressure turbo-generating unit that will take the surplus of the exhaust from the hammers, particularly during the warmer months.

An argument favoring the installation of a new central plant was the desirability of distributing the purchased current from a central location, so that the company could avail itself of the low rate earned by combining the loads from the various shops and smoothing out the demand curve. Three-phase 60-cycle 4,600-volt current is supplied, and it is distributed at this voltage to each building, where it is reduced to service voltage by individual transformer substations. The current is metered as it comes in and as it goes out to the various shops or departments, so that departmental charges for the service can be accurately rendered.

The main requirements of the new plant are to supply steam at 150 lb. pressure to the forty-one hammers in the forge shop, live steam to the various buildings for process work and to drive the vacuum pumps on the heating systems, compressed air at 100 lb. pressure to the shops and the central distribution of all electrical

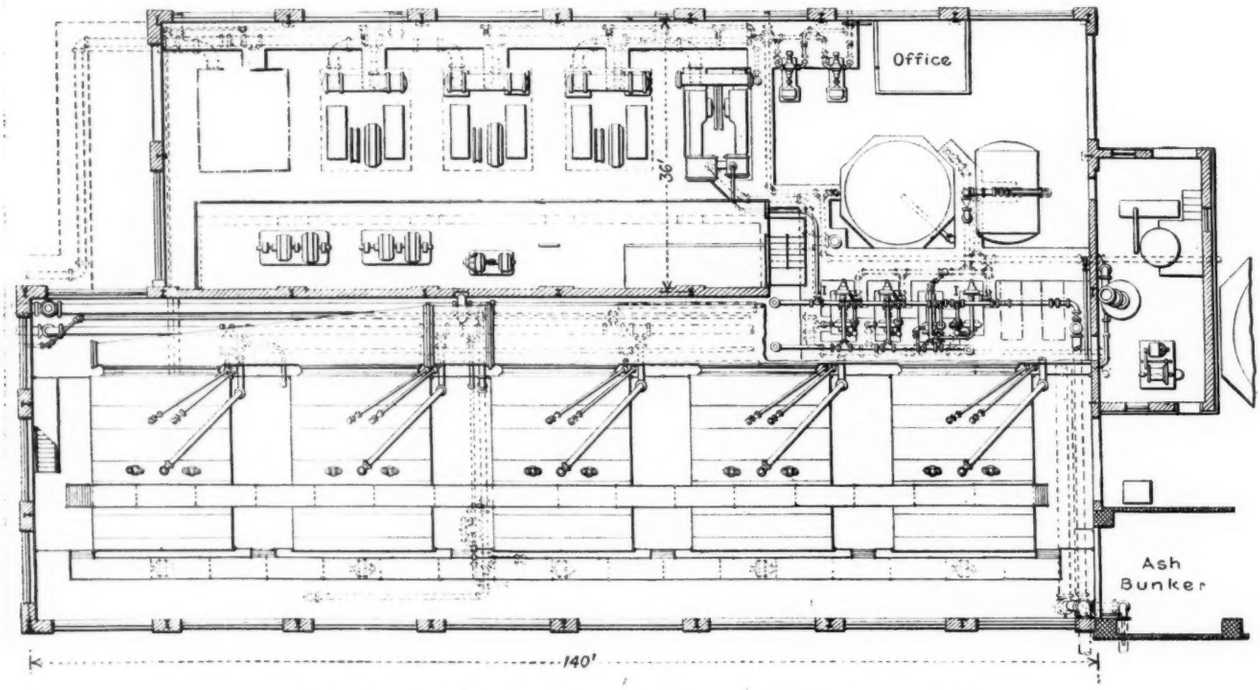

FIG. 1. BOILER AND ENGINE-ROOM ARRANGEMENT PLAN

energy required. When the company is working on a 24-hour basis, most of the hammers are in continuous use, so that the supply of exhaust steam is so nearly constant that the reserve in the 20-in. exhaust main connecting the power plants and the other buildings with the forge shop will serve to tide over momentary deficiencies.

The exhaust from the steam-driven air compressor and the boiler-feed pumps also passes to this main, and the feed-water heater has a connection to it. The pressure in this main is varied by means of back-pressure valves according to the heating requirements of the various buildings. It ranges from 0 to 5 lb. gage, but usually 3 lb. pressure is sufficient to heat the buildings in cold weather. During the warmer months the exhaust line is maintained at atmospheric pressure.

In four buildings at the present time there are 144,000 sq.ft. of direct radiation, a two-pipe vacuum system being employed in each building. It was considered advisable to locate a vacuum pump in each building and force the returns back to the power plant, to avoid maintaining under vacuum the long line from the plant to the various buildings. A leak in the system would then be segregated to the one building in which it occurred and would have no influence on the rest of the system. The vacuum pumps in the gear plant are of special design, with a steam cylinder at one end, a vacuum cylinder at the center and a pressure cylinder at the opposite end, all three cylinders being in tandem. In the other plants the returns from the heating system flow to a float receiver and are returned to the power plant by a separate motor-driven centrifugal pump.

All steam and water mains pass through a roomy tunnel from the power plant to the various buildings. It is 7 ft. high and has the unusual width of 14 ft. There is therefore an abundance of room to work on the piping and for employees of the power plant to pass from one building to the other. The electric cables are carried through underground ducts having no connection with the tunnel. Through this long run of tunnel expansion in the 20-in. exhaust main is taken care of by slip-sleeve expansion joints. In 1,800 ft. of main, four of these joints are installed. In the live-steam line expansion U-bends are used.

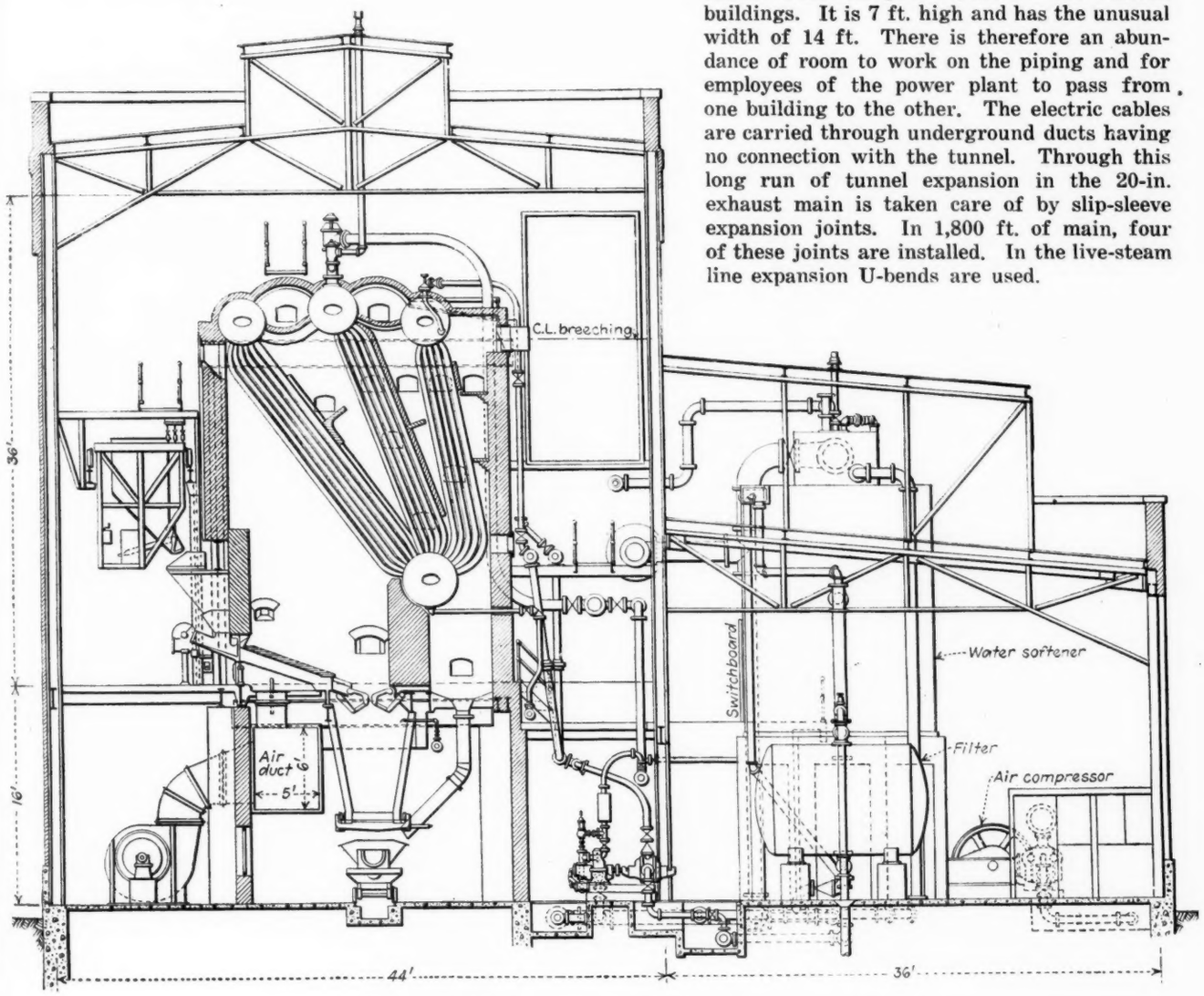

FIG. 2. TRANSVERSE SECTIONAL ELEVATION THROUGH PLANT

The power-plant equipment is high class in every respect and unusually complete in labor-saving devices and instruments to insure efficient operation. Reference to Figs. 1 and 2 shows the general layout. Steam is supplied by four water-tube boilers each having 8,227 sq.ft. of steam-making surface. They are designed for a working pressure of 200 lb., although the safety valves are set for 170 lb. and the operating pressure is 150 lb. The general arrangement of the setting is shown in the sectional elevation in Fig. 2. Under each boiler is an eight-retort underfeed stoker having an actual grate area of 189.5 sq.ft. Through a silent chain drive and sprocket each stoker is driven by a 20-hp. shunt-wound

motor with a drum controller giving a range of speed from 400 to 1,200 r.p.m. As indicated in Fig. 3, the motors are out in front of the stoker hoppers, where they are convenient to get at and do not occupy the more restricted aisle space between the boilers. Intermediate between the stoker and the motor is a lineshaft attached to the ram castings. By inserting removable links across the intervening space between the boilers, one motor may drive two stokers, and by inserting all three links, the four stokers may be driven by an auxiliary 8 x 8-in. vertical engine provided for emergency service.

Forced draft is supplied to the stokers by a combination of motor and turbine-driven fans, Fig. 4. No. 1 fan, having a capacity of 45,950 cu.ft. of air per minute, operating against a static pressure of 6 in. at 1,080 r.p.m., is driven by a 100-hp. shunt-wound adjustable-speed motor; No. 2 fan, with a capacity of 46,190 cu.ft. of air per minute and a speed of 1,567 r.p.m., is driven by a 90-hp. multistage turbine; No. 3 fan, with a capacity of 78,380 cu.ft. against a 6-in. static pressure at a speed of 1,151 r.p.m., or a capacity of 95,000 cu.ft. per minute at 1,151 r.p.m. against a static pressure of 4 in., is provided with a double drive consisting of a 160-hp. non-condensing turbine at one end and a 150-hp. squirrel-cage induction motor at the other end of the shaft. Pressure regulators control the speed of the turbines. The three fans discharge into a common duct from which damper-controlled uptakes lead to the windboxes of the stokers. With the variable-speed motor drive controlled from the boiler-room floor, steam turbines with pressure regulators and a combination turbine and constant-speed motor drive for the third fan, together with a variation in capacity with pressure, the arrangement is so flexible as to meet almost any operating condition. The fans are in the basement in a special room opening to the outside air and sealed off from the ash-handling aisle underneath the boilers.

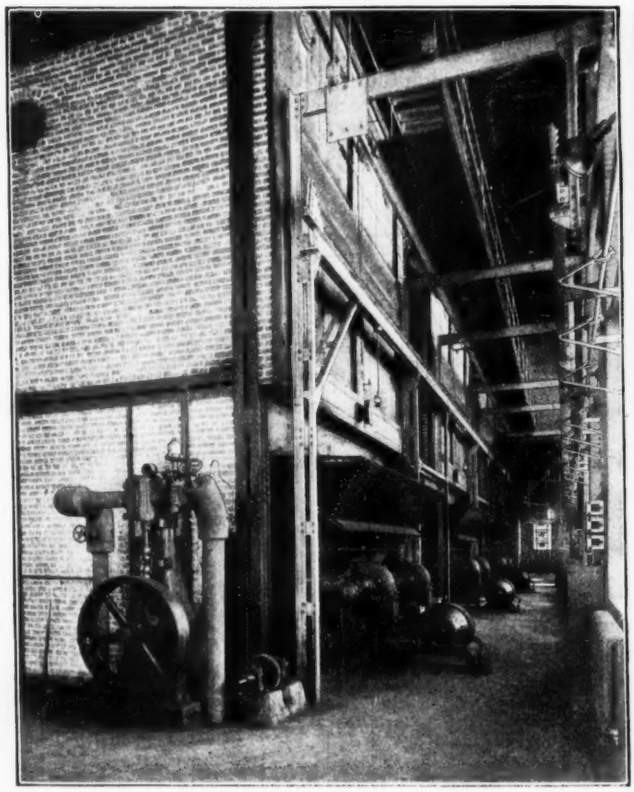

FIG. 3. A VIEW ALONG THE BOILER FRONTS SHOWING STOKER DRIVE

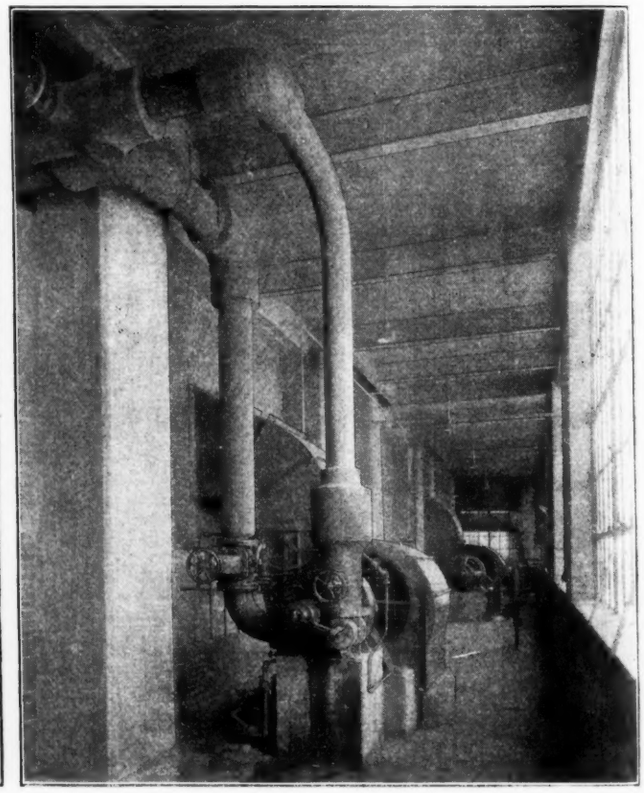

FIG. 4. FORCED-DRAFT FANS IN SEALED-OFF BASEMENT ROOM

SMOKE FLUE AND CHIMNEY

Gases from the boiler furnace pass out at the rear of the setting into a sheet-steel smoke flue leading straight to the stack. It is made of $\frac{3}{16}$-in. metal, unlined, and is of tapering section, increasing as it approaches the stack, where the area is $18 \times 8 = 144$ sq.ft. A radial brick stack 225 ft. high above the foundation with an internal top diameter of 12 ft. serves the four boilers. It is lined for the first 50 ft. At the base of the column the wall thickness is 30 in. and at the top $8\frac{1}{2}$-in., the approximate weight above the foundation being 1,015 tons. At the boiler outlet the available draft is 1.3 in. of water, and in the furnace it is reduced to something under 0.2 in. In the stoker windbox the pressure varies from $1\frac{1}{2}$ in. to 6 in., depending on the load, the depth of the fuel bed and the character of the coal.

By the operating force an effort is made to maintain operating conditions as near to the values given in Fig. 5 as possible. These curves were made from calculated test performances on 12,000-B.t.u. coal, but the various values for the corresponding loads approximate closely to operating conditions existing in this plant.

Taking an assumed case with a boiler of 8,227 sq.ft. of steam-making surface, operating at 200 per cent of rating, the curves show 6,600 lb. of coal burned per hour with an air supply of approximately 22,000 cu.ft. per min., a combined efficiency of boiler and furnace exceeding 72 per cent, a furnace draft of 0.13 in., an

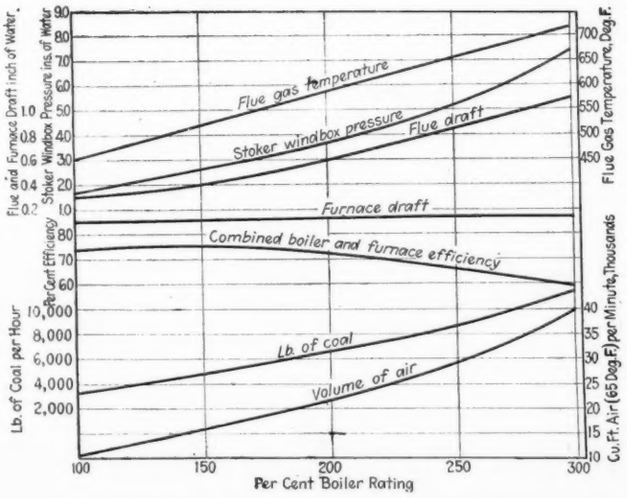
Flue and Furnace Draft, Inch of Water
Stoker Windbox Pressure, Ins. of Water
Flue Gas Temperature, Deg. F.
Per Cent Efficiency
Lb. of Coal per Hour
Cu. Ft. Air (65 Deg. F.) per Minute, Thousands
Flue gas temperature
Stoker windbox pressure
Flue draft
Furnace draft
Combined boiler and furnace efficiency
Lb. of coal
Volume of air
Per Cent Boiler Rating

FIG. 5. PERFORMANCE CURVES CALCULATED FROM TESTS, USED AS OPERATING GUIDE

uptake draft of 0.6 in., a windbox pressure of 3.7 in. and a flue-gas temperature approximating 590 deg. F.

With the foregoing operating conditions in mind, it may be of interest to review the relative proportions of grate, heating surface and gas passages. The boiler contains 8,227 sq.ft. of steam-making surface and 189.5 sq.ft. of grate. The smoke flue measurement at the stack is 144 sq.ft. and the stack area at the top, 113 sq.ft. It is evident that the ratio of active grate area to steam-making surface is 1 to 43.4, and per 100 sq.ft. of steam-making surface there are provided 2.3 sq.ft. of connected grate, 0.44 sq.ft. of flue area and 0.34 sq.ft. of stack cross-section. In daily operation an evaporation of from 8.5 to 9.5 lb. of water per pound of West Virginia coal averaging about 14,000 B.t.u. per lb. is obtained. Feed-water temperatures range from 200 to 220 deg F., depending on the back pressure carried in the 20-in. exhaust-steam main.

Handling of Coal

Coal is brought to the plant in railway cars and for storage is unloaded into a dumping pit having a capacity for four cars, from which it is picked up by a locomotive crane and transferred to the storage yard. If the coal is for immediate use, it is dumped into a track hopper at the power plant and elevated to the overhead bunker. From the track hopper an apron conveyor 30 in. wide and belt-driven from the coal cracker at a speed of 20 ft. per min. transfers the coal first to the crusher, from which it passes through a rotary four-bucket filler into a continuous bucket conveyor delivering the coal to the overhead bunker, the latter having a capacity to hold 360 tons, which is sufficient for a two-days' supply at full capacity. The coal cracker, which crushes to 1½-in. stoker size, has a capacity of 50 tons an hour. It is driven by a 25-hp. induction motor. The bucket conveyor has a speed of 43 ft. per min., a capacity of 50 tons per hour, and is driven by a 10-hp. motor. The conveyor and cracker motors have manual interlocking control.

From the bunkers the coal flows through any one of four duplex cutoff gates 24 in. square into a traveling weigh larry of the electrically operated suspended type, with the usual scale and registering beam. The larry has a capacity of 4,000 lb., and as it runs on roller bearings, is propelled by means of a 5-hp. motor or by hand if necessary, by means of a chain and wheel provided for this purpose.

Ash and Soot Handling

Under each stoker is an ash hopper of steel frame and plaster and hyrib construction protected on the inside by 4 in. of paving brick. The hopper has a capacity of 360 cu.ft., which is sufficient for four dumps. As shown in Fig. 6, the ash hoppers are double-gated with double racks and pinions. Back of the bridge wall two 10-in. diameter soot spouts per boiler are provided below the boiler-room floor with a slide gate at the top of each spout. At the center the spout has a hinged elbow so that it may be swung back out of the way when not in use.

From the hoppers the ashes drop into tip cars, holding 27 cu.ft., to be dumped into a 30-cu.ft. skip hoist of the

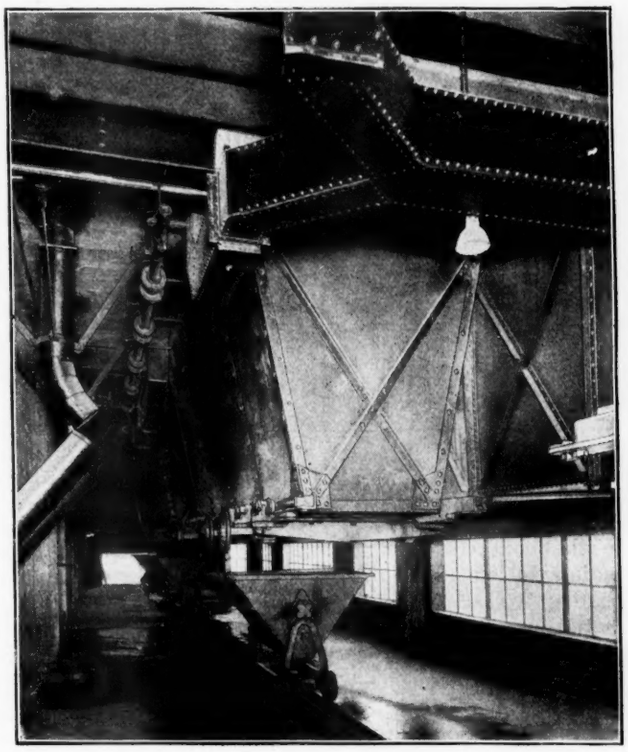

FIG. 6. ASH HOPPERS; SOOT CHUTES ARE SHOWN AT THE LEFT

compensating type with sectional counterweights and a travel of practically 90 ft. It is operated by an 11-hp. slip-ring induction motor with intermittent duty cycle control consisting of a traveling cam limit switch, an 8-in. brake, cover travel limit switches, push-button station, overload and dashpot timing relays, etc. The ashes are dumped into a 50-ton compartment at the end of the coal bunker and through duplex valves are discharged through hinged chutes to the railway cars delivering the coal.

Water from the Detroit River is considered fairly good for boiler use and is used generally throughout the city for this purpose without softening. However, this water contains over 7 grains of encrusting solids per gallon, and it was therefore decided to equip the new plant with a combination heater and water-softening apparatus. Operation at high rating was anticipated and it was the desire to insure continuous operation with less frequent laying up for cleaning and at the same time obtain the highest economy possible by removing the suspended and scale-forming ingredients before the water reached the boiler. The apparatus installed consists of a sedimentation tank surmounted by a heater, the former having an uptake funnel to settle out the precipitate of the solids and a conical bottom to permit the removal of the solids through the blowoff valves.

The heater has two compartments, one for heating 18,000 gal. per hour of makeup water and one for heating 14,400 gal. per hour of condensate returning from the various buildings. This condensate passes directly to the boiler-feed pumps without going through the sedimentation tank of the filter. The heater has a float-controlled regulating valve with devices for automatically admitting the raw water to its compartment as rapidly as required to supply the boiler-feed pumps after all the condensate which flows to its compartment without control has been used. If the condensate returns more rapidly than required by the pumps, it will fill in its compartment to a level where it will spill over the division plate into the top of the sedimentation tank, which has its shell extended to provide a storage capacity of 2,700 gal. before overflowing. The remainder of the equipment consists of a horizontal sand filter 8 ft. in diameter by 11 ft. long, a chemical proportioner, solution tank with agitator, and a set of solution pumps driven by a 5-hp. induction motor. The water softener operates under back pressures up to 5 lb. and is fitted with a float trap for draining the drips from the separator and also the overflow from the softener.

Before the installation of this combination softener and heater the boilers had been in operation for three months at ratings of 200 per cent and over. The scale was thick in the tubes underneath the mud pan. The softener has been in service just a year and the boilers show practically no scale at all, and during this period the benefit of clean heating surface has been obtained.

Although the raw water will vary considerably throughout the year and with the seasons, it averages about seven or eight grains of encrusting solids to the gallon. In the softener these impurities are reduced to 1 or 1½ grains per gallon by the use of soda ash and chemically pure hydrated lime. The treatment averages about ¾ lb. of soda ash and approximately 1¼ lb. of lime per thousand gallons of water, at a cost of 2c. to 2½c. for the chemicals. These figures, of course, are only approximate as the treatment must be varied as the analysis of the water changes. Titration tests are made daily with phenolphthalein and methyl orange in combination with a standard solution of sulphuric acid as detectors for alkalinity. These tests are simple to make and the results obtained are referred to a chart provided by the maker of the softener, which shows at a glance whether the right proportions of chemical are being used or whether it is necessary to increase or decrease either the lime or the soda ash.

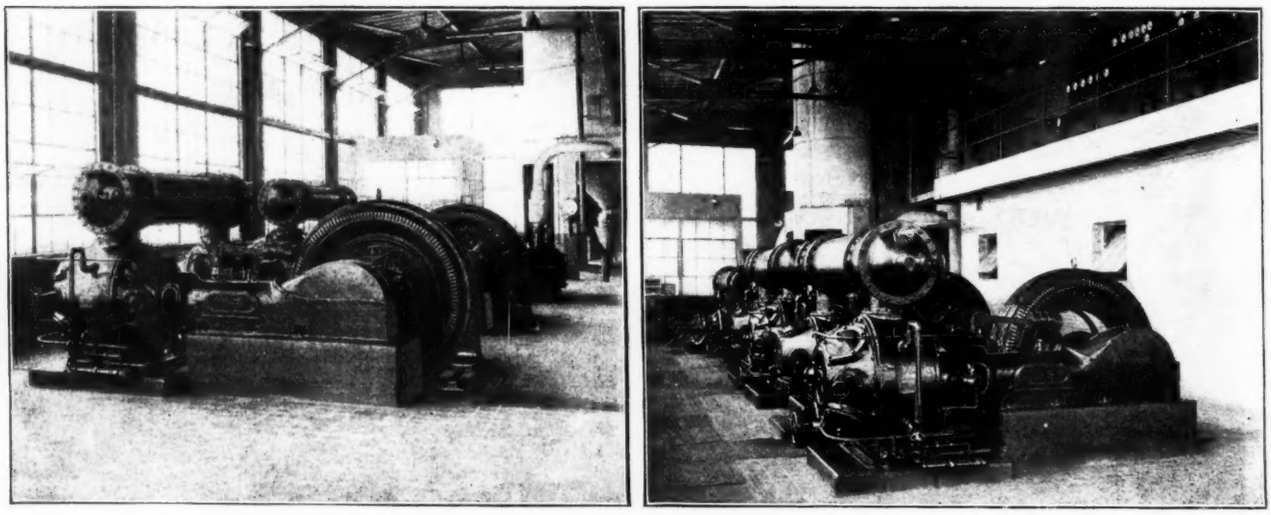

FIG. 7. VIEWS IN ENGINE ROOM SHOWING AIR COMPRESSORS, SWITCHBOARD GALLERY AND SOFTENING APPARATUS IN BACKGROUND

For handling the feed water, the plant has four pumps. Three are four-stage centrifugal pumps driven by steam turbines at a speed of 2,900 r.p.m. against a head of 512 ft. One of these pumps has a capacity to deliver 300 gal. per min. and the other two, 200 gal. per min. each. The turbine ratings are 65 and 55 hp. respectively. The fourth pump is a duplex direct-acting steam-driven unit with cylinders 10 and 6 x 12 in. and a capacity of 100,000 gal. an hour when the pump is operating at forty strokes a minute. The pumps are under the control of pressure governors, and each boiler has a water regulator to control the amount of feed.

An important factor in maintaining high operating economy and in distributing the cost of steam, compressed air and electricity to the various plants, is the full complement of instruments that has been provided. Each boiler has a steam-flow meter, a three-in-one draft gage to show the draft at the uptake, in the furnace

and in the windbox, an indicating pyrometer with a scale range from 0 to 1,200 deg. F. and a 5-point switch to show the temperature of the gases leaving the boilers, and the usual pressure gages. All high-pressure and low-pressure steam lines to the various buildings are equipped with flow meters, there is a water-flow meter on the makeup to the softener and another type of flow meter giving the pounds per hour and the temperature of all water entering the boilers. A neatly arranged gage board has instruments to record and indicate all exhaust and live steam, compressed air and water pressures. There are revolution counters on the air compressors and, as previously stated, all electric current is metered, first as it comes in from the central-station mains and on each line as it is fed out to the various plants.

Air Compressors

In the engine room are the three air compressors shown in Fig. 7. One is of the heavy-duty duplex steam-driven type with steam cylinders 12 and 25 by 16 in., and air cylinders 13 and 23 by 16 in. The other two are also heavy-duty duplex machines directly driven by 300-hp. synchronous motors at a speed of 225 r.p.m. The air cylinders are two-stage, water-jacketed and with an overhead intercooler having 241 sq.ft. of cooling surface. The dimensions of the cylinders are 14 and 22 by 16-in. stroke. Each machine is capable of delivering 1,322 cu.ft. of free air per minute at full load, the final discharge pressure of the air being 110 lb. There is plenty of space in the engine room for future air compressors should they be needed or for the low-pressure turbo-generating unit now under consideration.

All incoming cables furnishing the electrical energy for power and light enter a concrete cable vault underneath the engine-room floor. Above the vault is the primary room where all distributing oil switches and all watt-hour meters measuring incoming and outgoing current are located. On the gallery above is a nine-panel switchboard made up of black marine finished slate. It is equipped with a full complement of operating instruments and switches to control the various motors in the plant and the lighting. On the same gallery are two synchronous motor-generator sets to transform the incoming 4,600-volt three-phase 60-cycle current into direct current for the stoker and forced-draft fan motors. The motors are rated at 225 hp. and the generators at 150 kw., 250-volt each, the speed of the units being 900 r.p.m. One set is sufficient to supply all the direct current needed, the other being held as a reserve unit. There is also a 46-hp., 220-volt induction motor-generator set rated to deliver 30 kw. at 125 volts, direct current, for the excitation of the synchronous motors driving the compressors.

In the distribution of the current there are some novel features relative to the lighting and the power circuits. This is particularly true in the gear shop. The layout of the distributing feeders and the distribution panels was so made as to give a uniform volt-ampere rating per square foot of floor area. The shop is equipped with a great number of machines and practically all have individual motor drive, the motor sizes varying within comparatively narrow limits. It is thus possible to place machines anywhere on the manufacturing floor and then interchange or move them in the future to any desired location without additional wiring expense except perhaps a short run from a near-by panel board. The volt-amperes of main feeder capacity per square foot of floor space in this particular shop averages 22.6. The details of the system have been given previous mention elsewhere, so that there will be no occasion to enlarge upon this simple and convenient method of electrical distribution.

For the design and erection of the plant credit is due the Du Pont Engineering Co., of Wilmington, Del.

PRINCIPAL EQUIPMENT OF CENTRAL PRODUCTS COMPANY POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Stirling	8,227-sq.ft.	Generate steam	150-lb. pressure, underfeed stokers	Babcock & Wilcox Co.
4	Stokers	Underfeed	8-retort	Serve boilers	Motor-driven	Westinghouse Elec. & Mfg. Co.
1	Engine	Vertical	8x8-in.	Auxiliary stoker drive		Buffalo Forge Co.
1	Fan	Double conoidal	45,950 cu.ft. per min.	Forced draft	6-in. static press., 1,080 r.p.m., 100-hp. Westinghouse shunt motor	Buffalo Forge Co.
1	Fan	Double conoidal	46,190 cu.ft. per min.	Forced draft	6-in. static press., 1567 r.p.m. 90-hp. Moore turbine	Buffalo Forge Co.
1	Fan	Conoidal	78,380 cu.ft. per min.	Forced draft	6-in. static press., 1151 r.p.m., 161-hp. Moore turbine and 150-hp. Allis-Chalmer's ind. motor	Buffalo Forge Co.
1	Chimney	Radial brick	225-ft. high, 12 ft. diam.	Serve boilers		Alphons Custodis Chimney Cons. Co.
3	Pumps	Centrifugal	4 in., 300 g.p.m.	Boiler feed	4-stage, 2900 r.p.m., 55 and 65-hp. Terry turbines	Manistee Iron Works Co.
1	Pump	Duplex	10x6x12-in.	Boiler feed	100,000 g.p.h. at 40 strokes per min.	Worthington Pump & Machinery Co.
1	Conveyor	Bucket	50 tons per hour	Handle coal	10-hp. G. E. induction motor	C. W. Hunt Co.
1	Conveyor	Apron	30-in. wide	Handle coal	Belt-driven, 20 ft. per min.	C. W. Hunt Co.
1	Coal cracker		50 tons per hour	Crush coal	Driven by 25-hp. ind. G. E. motor	C. W. Hunt Co.
1	Weigh larry	Suspended type	4,000-lb.	Weigh stoker coal	Driven by 5-hp. motor	C. W. Hunt Co.
1	Skip hoist		30-cu.ft.	Handle ashes	Driven by 11-hp. slip-ring and ind. motor	C. W. Hunt Co.
3	Tip cars		27-cu.ft.	Handle ashes		C. W. Hunt Co.
1	Heater and water softening apparatus	Hot process	32,400-g.p.h.	Treating feed water	Chemicals, lime and soda ash	Harrison Safety Boiler Works
1	Air compressor	Heavy-duty duplex	Steam 12x25x16-in.; air 13x23x16 in.	Compressed air	110-lb. press.	Ingersoll-Rand Co.
2	Air compressors	Heavy-duty duplex	14x22x16-in.	Compressed air	110-lb., driven by 300-hp. G.E. syn. motors	Ingersoll-Rand Co.
2	Motor-generator sets		225-hp.—150 kw.	Direct-current for motors	Syn. motor, comp. d.c. gen.	Westinghouse Elec. & Mfg. Co.
1	Motor-generator		46-hp.—30 kw.	Excitation syn. motors	Ind. motor, comp. d.c. gen.	Westinghouse Elec. and Mfg. Co.
1	Crane	Locomotive	1½-cu.yd. bucket	Storage coal	Vertical boiler, 400 sq.ft., 125 lb. press.	Orton & Steinbrenner Co.
2	Pumps	Single-stage, volute	500 g.p.m.	Service pumps	Driven by 30-hp. Westinghouse Ind. motors, 1750 r.p.m.	American Well Works
1	Pump	Underwriters' fire	18x10x12 in.	Fire service		Worthington Pump and Machinery Co.

Consolidated safety valves, Lagonda non-return and stop valves, Chapman gate valves, Cadman blow-off cocks, B. & W. angle-blow-off valves, Northern Equipment Co., feed-water regulators, Reliance water columns, Ashcroft steam gage, Diamond soot blowers, G., E. and Republic steam-flow meters, Precision draft gages, Cutler-Hammer Auto-Starters for motors, Mason fan regulators, Bailey fluid meter, Schaeffer & Budenberg gage board, Brown pyrometer and revolution counters, Westinghouse switchboard, G.-E. transformers, S. F. Bowser lubricating oil tanks, Chicago Bridge & Iron water tanks.

Operations of Condensers

By W. H. MOTZ*

THE standard atmospheric ammonia condenser with its single gas connection at the top of the coil and its single liquid connection at the bottom is a type of condenser that is preferred by many operators. The arrangement of the connections to the coils is simple and practical. The condensing water is simply showered over the coils by the troughs. It has no small liquid drain connections that tend to rust away from the action of the water and the air. Leaks along the condenser pipes are easily discovered and readily stopped temporarily by a clamp and a rubber gasket. Leaks at the joints should be marked and repaired during the overhauling or shutdown period.

This type of condenser has a great advantage of being more nearly foolproof than any other type. However, at present it is being replaced somewhat by the newer designs of atmospheric condensers.

Water Distribution Over Atmospheric Condensers

The securing of a proper water distribution over the individual condenser coils is a point of no small importance. The condenser is installed to conduct heat from the ammonia to the water; therefore, it is essential to obtain an even distribution of water over all the pipes from end to end. The writer recently inspected an atmospheric condenser installed on the roof of a plant in Milwaukee, in which a large number of the pipes were securing water along only about half of their

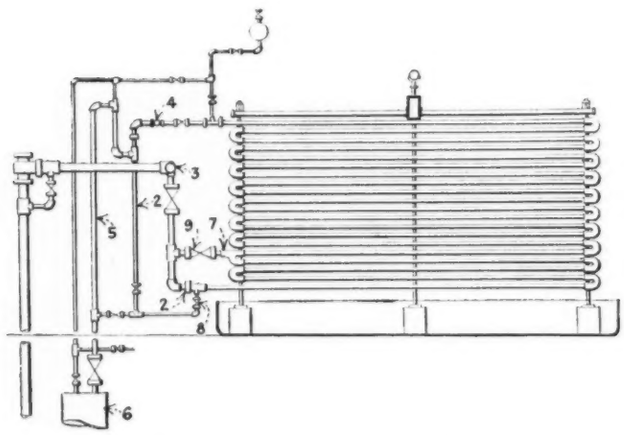

FIG. 1. FLOODED TYPE OF CONDENSER

length. It is evident that this was an expensive way of operating the plant.

In actual operation proper care is not always given to leveling the water-distributing trough. The holes and slots in the trough tend to clog with algæ, moss and other foreign material. These conditions affect the efficient distribution of the water. The writer believes that the galvanized troughs with serrated edges give the best service, everything being considered.

In order to determine whether the water is being distributed in the proper manner over each coil, the temperature of the water leaving the condenser coils should be ascertained. If there is a wide variation of temperature of the leaving water, it is on account of an uneven distribution of water to the sections. This is, of course, subjected to the assumption that the flow of ammonia to the coils is even and equally distributed to the various sections. To obtain the lowest possible condenser pressure, the water should have the same range of temperature in passing over each coil.

Cleaning of Atmospheric Condensers

The cleaning and the keeping clean of the condensing surfaces are of primary importance. The function of the surface is to conduct heat from the ammonia to the water. Therefore, it is not logical to allow the pipes

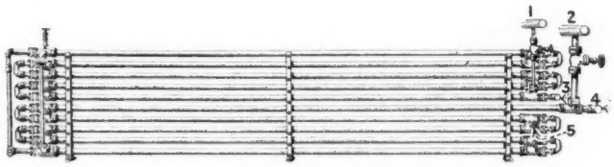

FIG. 2. DOUBLE-PIPE FLOODED CONDENSER

to become coated with a heavy layer of hard scale, which will necessarily retard the flow of heat. Heavy scale increases the condenser pressure and thus makes the plant more expensive to operate.

As the water flows over a condenser, there begins to form in the troughs and on the upper pipes a sort of greenish slime. This gradually works downward and finally covers the entire condensing surface; it is deposited by nearly all kinds of water, but of course the amount, etc., will vary with the locality. If this foreign material is allowed to remain on the condenser, it will harden into a scale. This begins at the top of the condenser, where the temperature is highest, and will gradually scale downward, as the efficiency of the higher pipes is being lowered by the accumulation of scale.

In the first place, it is evident that the scale should not be allowed to harden on the pipes. This may be prevented by washing the coils daily with a jet of water at high velocity. Rubbing the pipes with a stiff wire brush is a good practice.

In the second place, if hard scale is allowed to form, it should be removed carefully and thoroughly. Scale may be removed from the pipes by means of a rasp or a chipping hammer. Chipping hammers should not be so sharp as to injure the pipe, for careless use of the cleaning tools may result in split pipes or injuries that will promote pitting and corrosion. After the coils have been thoroughly cleaned, they should be covered with a good paint.

The inside surface of the condenser pipes should be kept as free as possible from oil and other matter. As oil is necessary for the lubrication of the compressor, more or less of it finds its way over into the condenser. After the plant is shut down, some of the condenser coils should be opened and examined for oil and foreign matter, after pumping out the coils, of course. To clean the coils the following procedure can be followed:

A steam connection is made to the gas header and then all gas valves are closed. The coils are disconnected at the bottom. Then, by turning steam into the

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gas header and opening the gas valves in succession on each coil, the oil and foreign material are blown out of each section. The steam connection is removed and an air connection substituted. The coils are now blown out with high-pressure air to remove any condensed steam from the coil.

Valve seats and discs should be inspected. Gaskets for valve bonnets or housings, joints between valves and headers, and packing for valve stems should be renewed if the plant is to be operated continuously during the season. Other gaskets and packings should not be renewed unless it is certain they are not in first-class condition. If the bolts, studs or nuts are rusted considerably, they should be replaced by new ones.

Operation and Regulation of Flooded Condensers

The flooded atmospheric condenser with its complicated system of connections presents to the operator a somewhat more difficult problem than the standard atmospheric type. Fig. 1 illustrates one type of flooded atmospheric condenser. The water is distributed over the coil surface in the same manner as the standard type. The amount of ammonia gas to be delivered to each section is governed by the size of the injector nozzle in the special fitting 2. There has been difficulty in the past in properly distributing the load on the condenser coils by means of regulating valves. The amount of liquid introduced into the coils along with the gas through the fitting 2 depends on the suction action of the nozzle and may be regulated somewhat by the liquid valve 8. A further means of regulating the supply of gaseous ammonia to each section is provided by the valve 9 and the special return bend 7, which may be used under special operating conditions.

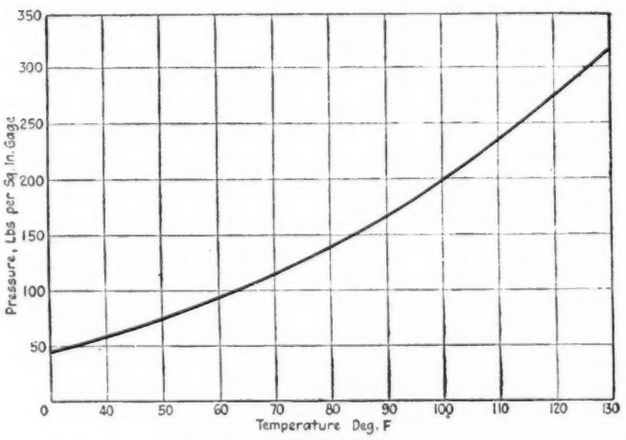


FIG. 3. PRESSURE-TEMPERATURE CHART FOR SATURATED AMMONIA

There is sometimes a tendency for the coils not to operate evenly under varying load conditions; that is, some of the coils under light load conditions would become filled with liquid, etc. This condition may be remedied by cutting some of the coils out of service or by using the proper-sized nozzles in the injection fitting 2.

This type of flooded condenser is more difficult to operate properly and regulate than the ordinary atmospheric type. It demands closer attention and inspection.

The flooded double-pipe condenser is illustrated by Fig. 2. This type of condenser must be controlled by regulating the amount of gaseous ammonia admitted to each section by means of the ammonia-regulating valve. To ascertain whether all the coils are condensing evenly, the ammonia gas inlets and pipes where the ammonia liquid leaves the coils, should be felt with the hand. If they are all of the same temperature, the coils are condensing alike. If a coil is hot, it is getting too much ammonia, and the regulating valve should be slightly closed. Likewise, if the coil is too cool, it is not being supplied with enough ammonia, so that the regulating valve should be slightly opened.

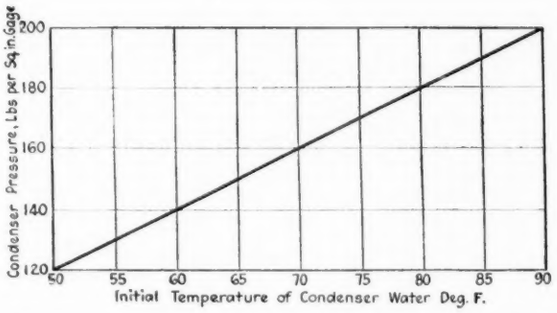


FIG. 4. CONDENSER PRESSURE-COOLING WATER TEMPERATURE CHART

The load on each coil or section is equalized in this manner, and the regulating valves should be manipulated so as to get the lowest condenser pressure possible with an even distribution of water to each coil.

It is evident that although the flooded condensers have larger capacities than the ordinary type and cool the condensed ammonia very near the initial temperature of the water, they are somewhat more difficult to operate in an efficient manner, and they demand closer attention and care.

Operation of the Double-Pipe Ammonia Condenser

The standard double-pipe ammonia condenser is similar to the standard atmospheric type in that it is as nearly foolproof as it is possible to make a condenser. There is no regulation of ammonia required. The entire performance of the various sections is controlled by observing the temperature of the water leaving the individual coils. These temperatures may be determined by inserting thermometers in suitable openings in return bends or tees or by feeling the last pipe at the end where the liquid ammonia leaves. The temperatures should be approximately the same in order for the coil to operate evenly. The water outlet valves on each section may be adjusted so as to give the same outlet temperature of water on all of the coils.

Cleaning of Double-Pipe Condensers

The removal of sediment and scale from the condenser surface is essential to the efficient operation of the condensers. The operator is under the disadvantage of not being able to see the condition of the inner tubes. Therefore, he must wait for indications of an accumulation of scale or take active proceedings to insure that scale will not be allowed to form. When the condenser tubes become coated with sediment and scale, the range of the temperature of the water in passing through the condenser decreases, and the other indication of dirt is an increase in condenser pressure. The operator should not wait for increased condenser pressure, but

he should clean the surfaces regularly. Of course the frequency and exact method of cleaning the tubes depend upon the nature and amount of material deposited and the nature of the plant.

The sediment in the tubes should be prevented from forming a hard scale by removing it. This is usually accomplished by reversing the direction of the flow of the water in the tubes for a few minutes each day or week, as the case may demand. This may be done by a proper connection of each section of condenser to wash-out headers by means of three-way cocks and valves. The wash-out water is allowed to flow to the sewer.

In the event that sediment is allowed to form into hard scale, it may be removed by a stiff wire brush or by a good tube scraper. This is fastened to a length of ½-in. or ¾-in. pipe and then pushed through the tubes to remove the scale. Thick and hard scale may be reamed from the tubes by fastening a drill upon the end of a length of ¾-in. pipe and then driving the drill through the tube with an air or electric motor, or by means of a pipe wrench. The tubes should be washed after cleaning in any of these ways.

Unusually High Condenser Pressure

An unusually high condenser pressure may be caused by a number of conditions. It has been shown how the accumulation of sediment and scale upon the condenser surfaces will cause an increase of pressure. If the quantity of condenser water is diminished, the pressure increases owing to the increased range of temperature of the water. Also, if the water increases in temperature, the pressure increases 2 to 3 lb. per degree rise. The system may be overcharged, which would submerge a part of the condenser surface. This would diminish the effective surface that could be available for condensing. On the other hand, a lack of ammonia in systems having flooded condensers of certain types will cause an increase of pressure. Probably the greatest cause of an unusually high pressure is the pressure of non-condensable gases in the condensers. Air may be drawn into the system through loose joints and stuffing boxes when the pressure in the system is below that of atmosphere, or air may have been left in the system after repairs have been made. A second source of non-condensable gases is the lubricating oil. This, by being heated in the compressor, vaporizes and generates gases that will not condense. The ammonia under repeated compressions and exposure to the higher temperature at the end of compression decomposes slowly into nitrogen and hydrogen. These various sources give rise to the presence of non-condensable gases in the condenser which displace ammonia from the available condenser surface, thereby increasing the condenser pressure.

In any event it is the duty of the operator to ascertain the cause of the increase of pressure and then proceed to remove the cause, for it is evident that increased pressure requires the expenditure of a greater amount of power to compress the ammonia. This adds to the cost of operation.

The presence of non-condensable gases in the condenser accounts for the unusually high pressure in most cases. Ordinarily, the pressure of the ammonia will be such that the temperature of the ammonia in the liquefying portion will be 5 to 10 deg. above the temperature of the water leaving the condenser. The temperature of the water of the condenser may be determined, and by adding 5 to 10 deg. to this, the temperature of the saturated ammonia may be obtained. Then, by reference to a table of the properties of saturated ammonia, the corresponding pressure may be ascertained. The operator can then compare this with the actual working pressure and note the difference. The gage pressures of ammonia corresponding to temperatures of saturation are shown by the curve in Fig. 3. The condenser pressure that should be obtained under ordinary conditions while the plant is in operation is shown by Fig. 4, with various initial temperatures of condenser water. The pressures indicated on this figure are considered good practice. If the pressures are materially above those indicated in Fig. 4 for the various initial temperatures of condenser water, the operator should suspect the presence of non-condensable gases in the condenser and should proceed to remove them.

Purging of Ammonia Condensers

The purging that is required varies considerably with the type and size of plant. In some plants it may be necessary to purge the condenser weekly, while others would need to be purged only every month or so. It is apparent that an excessive amount of purging causes a waste of ammonia and should be resorted to only when the pressures demand it. In order to remove the non-condensable gases, the coils should be allowed to become as nearly full as possible with liquid, and then should be cut out of service by the manipulation of the proper valves.

The condensing water should be allowed to flow for two to five hours over the sections to be purged, to allow the ammonia to condense and the gases to separate from the liquid ammonia. The purge valve on each section or at the top of the condenser should be connected to a pail or barrel of water, if it is desirable to eliminate the disagreeable odor of ammonia. The purge valve should then be opened only slightly. As long as the permanent gases are passing into the water, it will simply bubble. But as soon as ammonia comes into the water, the familiar cracking sound is produced, which is similar to the sound of steam being introduced into water, and the purge valve should be closed immediately. After an interval of a few minutes, the process should be repeated. Usually, a few purgings in this manner will remove all of the non-condensable gases from the condenser.

Action of Electrolyte and Elements in a Storage Battery

By L. W. Webb

The lead storage battery, or accumulator, consists of a positive element (peroxide of lead) and a negative element (metallic sponge lead) immersed in a dilute solution of sulphuric acid of about 1.220 to 1.280 specific gravity; this solution is called the electrolyte. While discharging, this cell gives from about 2.15 volts down to 1.76 volts. The unit of measure for the input, output and capacity of the battery is the ampere-hour; that is, the average number of amperes flowing through the battery during discharge from 2.15 down to 1.76 volts, multiplied by the number of hours the current has been flowing gives the rating of the battery in ampere-hours. The rating is usually on a 10, 8, 5 or 1-hour basis, depending upon the service the battery is used for. A battery rated at 80 ampere-hours on an 8-hour basis

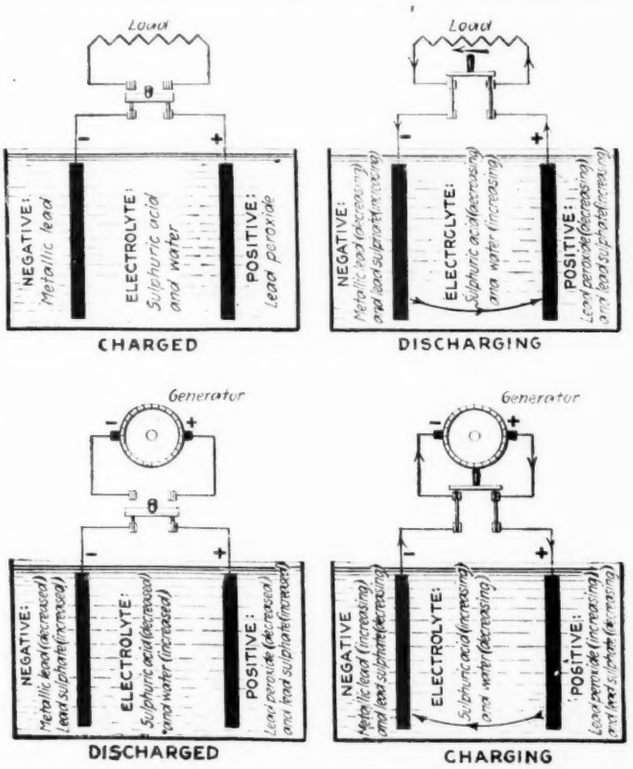
would have a lower rating on a 5- or a 1-hour basis, due to the inability of the free electrolyte to penetrate the pores of the plates fast enough to supply the demand. Furthermore, the higher the charge or discharge rate the greater are the chances for damage to elements due to buckling or shedding of active materials.

Consider a cell fully charged and just beginning to discharge. The electric current passing from plate to plate through the electrolyte tends to break up the water into hydrogen and oxygen. The hydrogen being released at the lead-peroxide plate combines with some of the oxygen in that plate and again forms water, reducing the lead peroxide to lead oxide. The oxygen released at the metallic lead plate combines with it to form lead oxide. If this discharge was continued indefinitely, both plates would therefore become lead oxide; but they never reach this state, for the discharge cannot be efficiently continued below 1.76 volts, because as the plates approach the same composition, the voltage difference between them decreases; this explains one reason why the voltage drops during discharge. The lead oxide on both plates is attacked by the sulphuric acid, and changed into lead sulphate; in fact, the formation of oxide and its reduction to lead sulphate are probably simultaneous. Since the change to lead sulphate takes some of the acid from the solution and water is formed during the process, the specific gravity of the acid decreases as the discharge progresses. Lead sulphate is a substance that has practically no conductivity and, when present in sufficient quantity, tends to fill up all the pores of the plates and restrict the current flow by preventing the free circulation of acid through the active materials. If the battery is discharged below 1.76 volts, lead sulphate causes an increase in volume of each of the plates, setting up strains in them and tending to buckle them and cause the active material to crack and drop off. The discharge should never be allowed to reach this point, and if stopped at 1.76 volts should give none of these troubles.

During the charge, just the reverse happens; that is, the sulphate on each plate is returned to the acid and the plates are restored to their original condition. This causes the specific gravity of the acid to increase to its original strength, and even slightly above, owing to the loss of water by evaporation and by the escape of oxygen and hydrogen gas from the positive and negative plates respectively. This loss must be made up by adding distilled water to the electrolyte and never by adding electrolyte, as that would not reduce the specific gravity. The charge should continue until all the sulphate on the plates is returned to the acid; this operation is complete when both the voltage and specific gravity of the acid become constant and the cell is gassing freely.

As neither the sponge lead nor the lead peroxide has much mechanical strength, some means must be taken to hold them fast in their respective plates. This is usually done by designing the supporting grids so as to take all mechanical strains and at the same time make good contact with the active material. It is important that they undergo no chemical changes themselves and that there be no local action between them and the active material. The electrolyte does not penetrate very far into the active material and there is therefore no need to make plates very thick. The only reason for increasing their thickness is to lengthen their life, and this should be only sufficient to make up for normal loss resulting from local action and shedding of the active material due to incomplete conversion of the sulphate on the plates back into acid during the charge. When cells have been allowed to remain any length of time in a discharged condition, the sulphate becomes very hard and brittle, and when the battery is placed on charge, small quantities flake off and fall to the bottom of the jar. This results in loss of active material and gradual disintegration of the plate. The positive plate is affected to a greater extent than the negative, as it has less mechanical strength; this is one reason why positive plates have a shorter life than negative.

The more porous the active material the greater depth the acid will penetrate to and the greater will be the capacity of the battery. The current must be distributed equally over the surface of each plate in order to insure an equal life of all parts, otherwise some portions would be worked more than others. Great attention must therefore be paid by the manufacturers and users that acid space, separators, etc., are properly proportioned or the maximum life of the battery will not be obtained.


Load
NEGATIVE: Metallic lead
ELECTROLYTE: Sulphuric acid and water
POSITIVE: Lead peroxide
CHARGED
Load
NEGATIVE: Metallic lead (decreasing) and lead sulphate (increasing)
ELECTROLYTE: Sulphuric acid (decreasing) and water (increasing)
POSITIVE: Lead peroxide (decreasing) and lead sulphate (increasing)
DISCHARGING
Generator
NEGATIVE: Metallic lead (decreased) Lead sulphate (increased)
ELECTROLYTE: Sulphuric acid (decreased) and water (increased)
POSITIVE: Lead peroxide (decreased) and lead sulphate (increased)
DISCHARGED
Generator
NEGATIVE Metallic lead (increasing) and lead sulphate (decreasing)
ELECTROLYTE: Sulphuric acid (increasing) and water (decreasing)
POSITIVE: Lead peroxide (increasing) and lead sulphate (decreasing)
CHARGING

CHEMICAL COMPOSITION OF BATTERY ELEMENTS AND ELECTROLYTE DURING DIFFERENT STAGES OF CHARGE AND DISCHARGE

The figure illustrates the chemical composition of the elements and electrolyte in a storage battery, and their changes during stages of charge and discharge.

Of the total number of water-tube and horizontal tubular boilers sold by members of the American Boiler Manufacturers Asso. during more than five months up to March, 1921, 60 per cent were of the horizontal return-tubular type and 40 per cent were of the water-tube type. A comparison between the square feet of heating surface of the two types, however, exactly reverses the proportion, thus showing plainly that the water-tube type of boiler is generally made for a larger capacity per unit than is the other type.

You, Mr. Watertender

The following was recently sent out by W. E. Thomson, steam-plant engineer of the Southern California Edison Co., to all watertenders of the company as an appeal to "sell them their jobs." It is well worth the attention of all boiler-plant employers.

Do you, Mr. Watertender, realize that you occupy an important position? You are largely responsible for the lives and safety of others as well as yourself. You have almost as much to do with the efficiency made by your shift as has the fireman. You are the one to see that the water is heated as hot as possible before it leaves the heater so that you gain by using all of the exhaust steam. Heating the water hot before it enters the boiler helps the boiler. It does not have to put so much heat into each pound of water, hence you increase the amount of steam the boiler can make. This increased capacity, especially over the peak load, enables your station to carry more kilowatts. Every eleven degrees you can heat the feed water by using exhaust steam means a saving of one per cent in the amount of fuel oil used on your shift, and almost one per cent gain in boiler capacity.

Watch the Water Level

By watching the water level in the boiler, you keep the boiler from going dry, perhaps exploding. At one of our plants someone did not watch the water level. The water in a boiler was allowed to get low—way out of sight in the glass. A tube burst. Luckily, no one was injured, as the force of the explosion happened to be sideways into the other tubes. But the whole front bank of tubes had to be renewed. The brickwork had to be repaired. The total cost was over eleven hundred dollars, besides the loss from having the boiler out of service.

It is you, Mr. Watertender, who must watch to see that the water does not get too high in the glass. If it does get too high, the water will go over into the steam main. The temperature of the steam is lowered. More steam is required to carry the same load. More oil has to be used to make the steam. Hence your shift efficiency suffers. But this is not all. If enough water goes over, it is likely to wreck some machine. An instance of this happened not long ago. An exciter was wrecked. Fortunately, no one was hurt, but the repairs cost over five hundred dollars, and for some time, until the parts were received from the factory, the other exciters were overloaded and the plant in danger of shutting down any minute. This water, going over into the turbines, corrodes and scales the parts, causing a loss not only to your shift efficiency, but to everybody else's until the machine can be taken out and overhauled.

Feed the Water Gradually

It is you, Mr. Watertender, who can help your fireman and your shift efficiency by feeding the water into the boilers gradually, not have a valve half open one minute and closed the next, but set the valves so that the water goes into the boiler just as fast as the steam-flow meter shows it is going out. It has been shown by tests that a swinging load will cause a loss of over 5 per cent, and that is just what you get when you feed the water into the boiler by spurts. You get the same action that a swinging load on the plant would cause. If you don't believe this, try it out. Take a reading on the flow meter, then open your feed valve wide and watch the flow meter—drops back, doesn't it? Now, close the feed valve and watch the flow meter—jumps right up, perhaps to a greater reading than you had at the start. Just the same action when you open the valve as if the station load would suddenly drop and the fireman had to cut back on his fires, only in this case the boiler stops steaming so fast, but you are using the same amount of fuel oil in the furnace. If the water is fed regularly, the flow-meter chart will not show any sudden swings and your shift efficiency will thus get the benefit.

Carry Water Level at Half a Glass

Did you, Mr. Watertender, ever stop to think that by carrying the water level constant at half a glass, your work is made easier and you are in a position to help the fireman out? A sudden demand comes for more steam. All right, you have a half-glass of water, a little extra, so you can shut the feed valve a minute—just long enough so that the boiler output increases because you are not putting cold water into it, but that minute gives the fireman a chance to get his steam pressure up. You can now open the feed a little—very gradually, remember, too fast will cause the steam to drop again—and slowly work your water levels up to half-glass again.

This little extra work on your part has kept the steam from getting away down so that both you and the fireman would have had to work for perhaps an hour to get it up. Now, suppose your water levels are back to half a glass again, and the fireman is carrying his steam high so as to get the best efficiency, a little load drops off, a boiler pops. All right; once more you can save. The boiler popping can stand a little more water; you open the feed valve. The popping stops almost immediately. The extra water you let in had to be heated. You have saved the steam that was going to waste through the pop valve. The fireman has now cut back on his fires a little so you can regulate the feed again until you have the half-glass of water showing in the gage.

Blowing Down the Boilers

It is you, Mr. Watertender, who is responsible for blowing down the boilers—for keeping the concentrate in the boilers below 200 so that the boilers will not prime. It is you who must keep the concentrate as near 200 as possible, so that heat will not be wasted by too much blowing down. Every time a boiler is blown down unnecessarily, it means a loss of approximately ten gallons of oil.

When a boiler is on stand-by, it is you, Mr. Watertender, who should report it in writing to the fireman if the boiler keeps filling up so you have to blow it down to keep the glass from getting full. It is you who should report it to the fireman if the stand-by boiler keeps losing water so you have to open the feed valve to keep the water in sight in the glass. In both these cases hot water is being wasted and you are in a position to catch these wastes before anybody else. A barrel of water wasted in either of these cases means a gallon of oil lost.

It is you, Mr. Watertender, who must blow down the water column and gage glass on each boiler at least once a shift so that you are sure the water level shown is correct. Otherwise these lines may become clogged, the glass show water and still the boiler go dry, perhaps explode, kill someone and wreck the plant.

Gas-Engine Crankshaft Failures

By William P. Flint

When a crankshaft for a gas engine is designed to be supported on several bearings and loaded between the bearings, it is quite evident that the punishment of the shaft will be much above normal if one bearing is slacked off or worn away so that it does not carry its

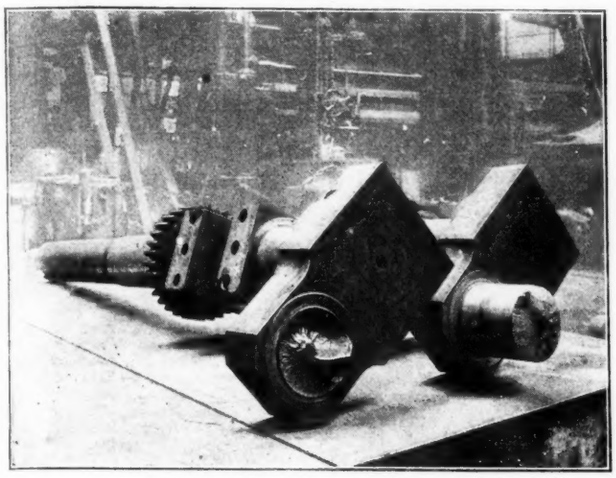


FIG. 1. FRACTURED CRANKSHAFT; NOTE CHARACTER OF BREAK

share of the load. This condition exists, to a greater or less degree, when a crankshaft is not maintained in good alignment. Premature ignition, or an ignition of the charge materially before the dead center, also causes abnormal strains in the crankshaft. Either of these conditions, if long continued, may lead to a failure of the crankshaft. Apart from faulty design, workmanship or material these are the chief causes of failure.

The reason they are not more generally recognized as the causes of failure is probably due to the way in which crankshafts fail. The writer has seen a number of broken crankshafts, and all have shown a general resemblance to Figs. 1 and 2, which are from photographs of two different shafts that failed in service. It should be noted that the fractures are more like what would be expected if the material were brittle like cast iron or glass, for there is no indication of stretching before fracture. In every case, however, in the writer's experience when a test sample has been taken as close to the fracture as possible, it has exhibited, when pulled, the usual "elongation" and "contraction of area" characteristic of forged steel.

An examination of the shaft shown in Fig. 1, while revealing no signs of elongation or contraction of area, showed in some areas a granular or crystalline fracture and in other areas a somewhat rubbed or polished appearance. The rubbed appearance was caused by the working and rubbing together of the two surfaces of an old crack which no doubt had been growing gradually for quite a long period of time. The granular or crystalline fracture represented the final break, which occurred suddenly.

An examination of shafts in actual service occasionally reveals incipient cracks which confirm the theory just given. Such cracks should always be looked for in the apparently sound portions of any crankshaft which has failed, before attempting to repair it. These cracks are easiest detected by supporting the shaft on lathe centers and cleaning off all surface oil and giving the shaft a coat of whitewash.

On turning the shaft over slowly, its weight will close all these surface cracks in turn, and oil from them will squeeze out and stain the whitewash. They may also be seen if a most painstaking examination is made of the shaft in place. These capillary cracks are usually found in the fillets where crankpins or shaft bearings join the crank cheeks. At such points there is a sudden change of section which concentrates the stresses in the shaft, much as a nick does in a piece of wire which is to be broken.

The liability to form cracks at the juncture of the crankpin and crank cheek is much reduced by the use of a liberal fillet and much increased by a sharp corner. The designer is limited in the use of large fillets because of the fact that they cut down the effective crankpin bearing area.

Once a capillary crack has started, it produces a concentration of stress at its ends and deeper portions, which results in a gradual extension of the crack. Such a crankshaft may operate for a considerable period, depending on the load and alignment, but eventually it must break. The correction of a fault in alignment which has caused a crack to start, will no doubt prolong the life of the shaft.

An inspection of the main bearing shown in Fig. 2 indicates a probable cause of failure in this instance since it is evident that the entire babbitt is gone, removing all journal support.

The occasional failure of a crankshaft is one reason for making the crankcase heavy and rigid. When the

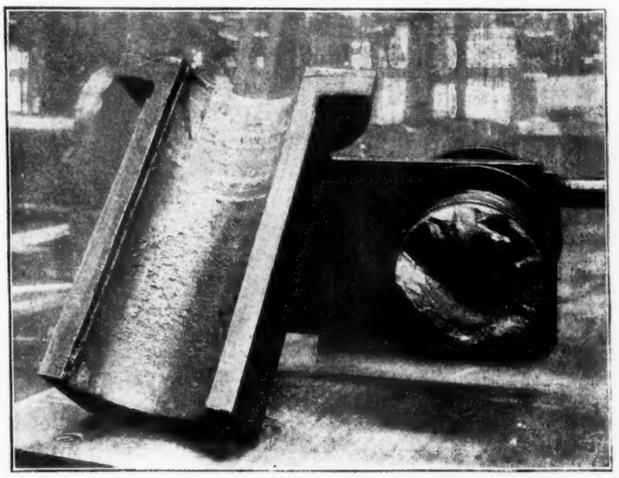


FIG. 2. CRANKSHAFT FRACTURED BY LACK OF BEARING SUPPORT

crankcase is strong, the damage is usually confined to the crankshaft. Well-designed crankshafts, properly taken care of, will usually operate for many years, but an occasional careful inspection is worth while.

The Greek government in 1917 expropriated all water-power rights, but it is understood that the government would not oppose exploitation of these resources by foreign capital and that assistance would be extended by local banks or otherwise. The total power available is estimated to be less than 500,000 hp.

Uncommon Armature Connections

By M. A. MEYERS
Electrical Engineer, The Maintenance Company, New York City

It is explained how 96 coils on an armature can be connected to form a six-pole series winding without leaving one coil dead and connecting two commutator bars together.

PERIODICALLY, there appears in the average repair shop for rewinding, or for a new commutator or both, an old Perrett ring armature with 96 coils and 96 commutator segments for a six-pole machine. Given to the old-time armature winder, probably no comment will be forthcoming, and nothing unusual will be heard of the job. But if turned over to a young winder, with no forewarning, the foreman is likely to be confronted with, "This armature is connected wrong. One of the leads is crossed and the commutator pitch varies. I don't see how it ever worked." He is correct in his enumeration of peculiarities, but his deduction that there is a mistake is erroneous.

The armature is series-connected and the total number of commutator bars and coils (96) being an even multiple of the number of poles, 6, each series of three coils will close on itself if connected in the ordinary way, as shown in Fig. 2. Coil No. 17 is shown with its beginning lead connected to bar No. 1 and its ending lead 32 bars advanced to bar No. 33. Coil No. 49, 32 coils farther around the armature, has its beginning lead on bar 33 and its ending lead advanced 32 to bar 65. Correspondingly, coil 81 is connected between bars 65 and 97, the latter being in reality bar No. 1, the starting point.

If the alternative suggests itself to try a commutator pitch of 1 and 32 instead of 1 and 33, there will follow 32 to 63 and 63 to 94, falling two bars short of becoming a regular retrogressive winding. If a commutator pitch of 1 and 34 is used, there will follow 34 to 67 and 67 to 100, two bars too far to become a progressive winding.

The simple way out would be to join or "jumper" two adjacent bars together, making a total of 95 instead of 96 bars, and leave one coil inactive or "dead." Then with a lead spread of 1 and 33, 33 and 65, 65 and 97, there would ensue a regular progressive winding, as with 95 bars No. 97 would in reality be No. 2.

However, the scheme used in the armature in question is not to leave a dead coil. What is actually done is to "jumper" two adjacent bars by means of a coil, leaving all coils active. The order of procedure is as follows: Connect all beginning leads 16 bars to the left. Then at any point on the armature connect one ending lead *A* 15 bars to the left; since the beginning lead is 16 bars to the left, this particular coil then connects two adjacent bars. The next 31 ending leads, at the left-hand side, connect 17 bars to the right, which brings the winder to the two bars jumpered by coil *A*. The remaining 64 leads are then connected 16 bars to the right.

Fig. 3 shows the same scheme where 24 coils and

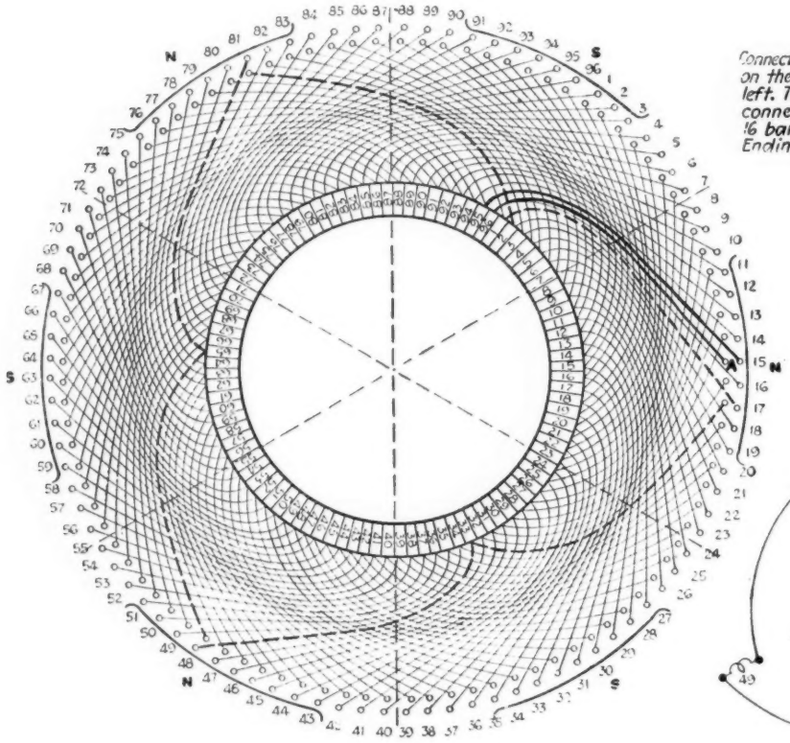


FIG. 1. SERIES WINDING WITH NINETY-SIX COILS CONNECTED FOR A SIX-POLE ARMATURE

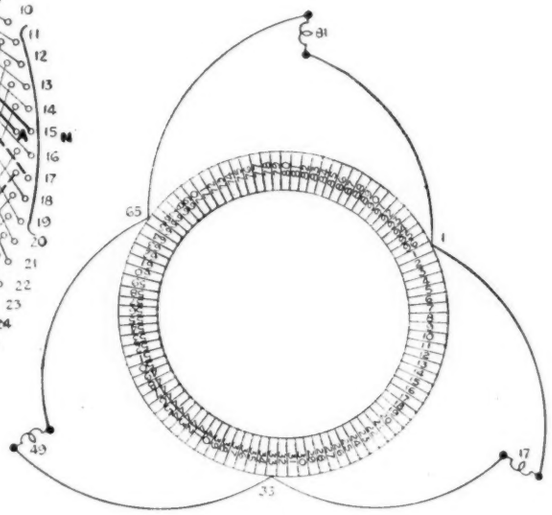

Connect all beginning leads 16 bars to the left. At any point on the armature connect one ending lead "A" 15 bars to the left. The next 31 ending leads (at the left-hand side) connect 17 bars to the right and the remaining 64 leads 16 bars to the right. Beginning leads are on outer circle. Ending leads are on inner circle.

FIG. 2. ONE SERIES OF COILS (FIG. 1) CLOSES ON ITSELF IF CONNECTED IN THE ORDINARY WAY

bars are used instead of 96. The beginning leads are on the outer circle and the ending leads are on the inner circle. In this case connect all beginning leads 4 bars to the left. At any point on the armature connect one ending lead *A* 3 bars to the left. The next 7 ending leads, at the left-hand side, connect 5 bars to the right, which brings the winder to the coil-jumpered bars. As the succeeding bar already has its quota of leads, the ending of coil 2 and the beginning of coil

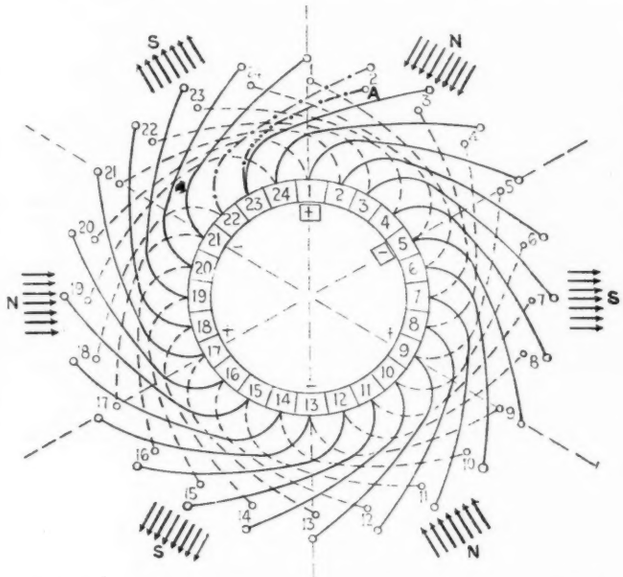


FIG. 3. SERIES WINDING WITH TWENTY-FOUR COILS CONNECTED FOR A SIX-POLE MACHINE

3 must be skipped and the remaining 16 leads connected 4 bars to the right instead of 5.

Starting with bar No. 1 and tracing through, the current paths will be:

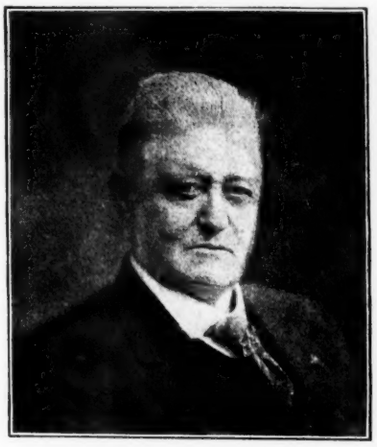
	Bar	Coil	Bar		Bar	Coil	Bar	
Brush—	1	5	9	Brush—	1	20	16	
	9	13	17		16	12	8	
	17	21	2		8	4	24	
	2	6	10		24	19	15	
	10	14	18		15	11	7	
	18	22	3		7	3	23	
	3	7	11		23	2	22	Jumper
	11	15	19		22	18	14	coil
	19	23	4		14	10	6	
	4	8	12		6	1	21	
	12	16	20		21	17	13	
	20	24	5—Brush		13	9	5	—Brush

There may be two, four or six sets of brushes, set on the neutral zones, shown by the diametrical dotted lines.

Engineer's Certificate Renewed Forty-Five Times

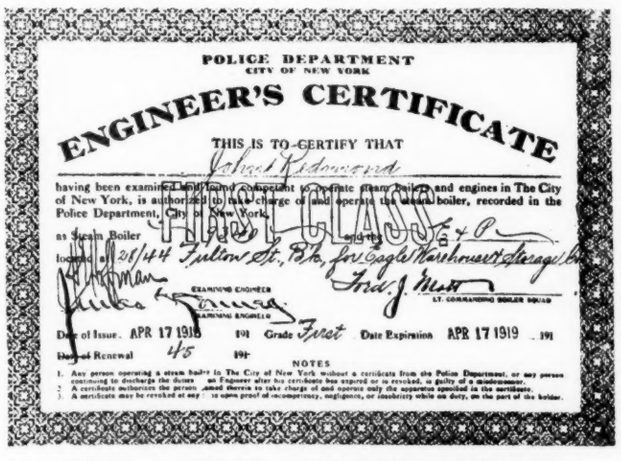
Probably of all the engineers' certificates issued by the Police Department of the City of New York, the one originally issued to John Redmond has been renewed the greatest number of times as the certificate that expired April 17, 1919, was the forty-fifth renewal as indicated in the reproduction shown herewith.

Mr. Redmond was born in Liverpool, England, Aug. 7, 1851. He served five years as apprentice to the machinist trade and later was employed as a machinist at the Thos. Brassey Locomotive Works and at Laird Bros. Shipbuilding Works and was for three years in charge of the Royal Rock Ferry Co.'s four steamers. He came to New York in 1871 and found employment with the Delamater Iron Works at the foot of West 13th St., leaving there to take charge of the shop of McAdams & Cartwright, the New York representatives of the Otis-Tuft Elevator Co., of Boston. Upon leaving this position Mr. Redmond shipped as engineer on the Williams & Guion line steamers, "Wisconsin" and "Wyoming." Upon leaving that company he went with the Vauxhall Engineering Co., of Liverpool, installing the engines and boilers in three steamships of the National Line and in one steamer of the West India Line. He then went to sea again as engineer on the National Line steamers "Erin," "Greece" and "Italy," and after fifty-three voyages across the Atlantic, he took charge of the building of Edward S. Jaffray at 350 Broadway, New York City, where he was employed for eleven years, during which time he was chief engineer of Mr. Jaffray's three yachts, the "Skylark," "Vedette" and the "Stranger."



JOHN REDMOND

Leaving there with a view of bettering his position, he took charge of the Gallatin National Bank Building, 36 Wall St., where he remained for twelve years, after which he was employed for seven years as superintendent and chief engineer of the Germania Bank, Spring Street and Bowery. He was then appointed chief engineer of the Atlantic Mutual Insurance Building, 49-51 Wall St., and retained that position until his retirement. He has since been engaged with engineering inventions.



POLICE DEPARTMENT
CITY OF NEW YORK

ENGINEER'S CERTIFICATE

THIS IS TO CERTIFY THAT

John Redmond

having been examined and found competent to operate steam boilers and engines in The City of New York, is authorized to take charge of and operate the steam boiler, recorded in the Police Department, City of New York,

as Steam Boiler FIRST CLASS

located at 28/44 Fulton St., Bklyn, for Eagle Warehouse & Storage Co.

Fred J. Mott
LT. COMMANDING BOILER SQUAD

EXAMINING ENGINEER

Date of Issue APR 17 1918 191 Grade First Date Expiration APR 17 1919 191

Date of Renewal 45 191

NOTES

1. Any person operating a steam boiler in The City of New York without a certificate from the Police Department, or any person continuing to discharge the duties of an Engineer after his certificate has expired or is revoked, is guilty of a misdemeanor.
2. A certificate authorizes the person named therein to take charge of and operate only the apparatus specified in the certificate.
3. A certificate may be revoked at any time upon proof of incompetency, negligence, or insobriety while on duty, on the part of the holder.

REPRODUCTION OF ENGINEER'S CERTIFICATE, FORTY-FIFTH RENEWAL

Mr. Redmond has English and American Marine certificates, also an American first-class stationary license.

The Design of Pipe Bends for Expansion in Pipe Lines

By J. G. STEWART

THE use of pipe bends for taking up expansion in pipe lines is increasing in accordance with modern practice, especially in high-pressure steam-pipe work, yet comparatively little has been published that will enable the engineer to determine readily how much expansion any particular pipe bend will dissipate within the limits of safety. Bends are made in such a variety of shapes, to suit particular cases, that an

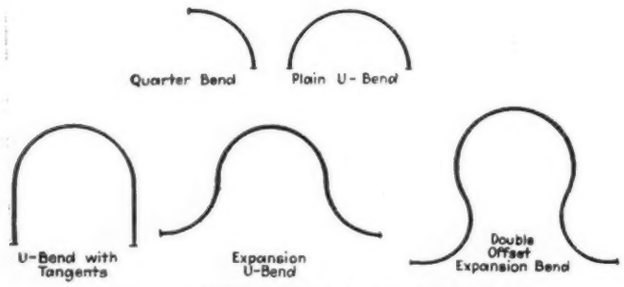


FIG. 1. COMMON TYPES OF PIPE BENDS

analysis of only the more commonly used ones is permissible here.

It is the purpose of this article to show the relative values of different types of bends and how they may be most effectively installed. Previously published articles have stated that the expansive value of the so-called "Expansion-U-Bend" is only twice that of a plain U-bend. That this assumption is erroneous is easily shown.

The derivation of an expression for the expansive value of an "expansion U-bend" is as follows: Let

D = Expansive value of the bend either way from the normal or unstrained position;
a = Mean radius of bend in inches;
d = Outside diameter of pipe in inches;
M = Bending moment;
E = Modulus of elasticity of the material;
I = Moment of inertia of a cross-section of the pipe;
P = Thrust in pounds;
S = Maximum fiber stress, pounds per square inch.

The deflection for one-half the bend is found, then this value doubled for the whole bend, since the two halves are symmetrical. The deflection at P (Fig. 2) is obtained in two steps by first considering the deflection in the length XY, assuming the outer leg XP to be rigid. The deflection in XP is then considered, assuming the portion XY to be rigid.

It is demonstrable by calculus that the horizontal component of the movement at P due to flexure of the bend in the portion XY

$$= \frac{a^3 P}{EI}\left(\frac{3\pi}{4} + 2\right) \qquad (1)$$

and that the corresponding movement at P due to flexure in the portion XP

$$= \frac{a^3 P}{EI}\left(\frac{3\pi}{4} - 2\right) \qquad (2)$$

Adding (1) and (2) and multiplying by 2 for both halves of the bend, we have $D = \frac{3\pi a^3 P}{EI}$. But for the condition of maximum fiber stress, $P = \frac{SI}{ad}$. Substituting this value of P,

$$D = \frac{3\pi a^3 S}{Ed}, \qquad (3)$$

which represents the total deflection of an expansion U-bend in one direction from the normal or unstrained position. The deflection of a plain U-bend may be found in the same manner to be

$$D = \frac{\pi a^2 S}{Ed}, \qquad (4)$$

which represents the deflection of a plain U-bend one way from the normal or unstrained position. It is thus seen that if the effect of the short tangents that are necessary at the ends of pipe bends for installing the flanges is neglected, the expansive value of an "expansion U-bend," as shown in Fig. 1, is three times that of a plain U-bend with the same radius, using the same size of pipe. The expansive value is seen to be independent of the thickness of the walls of the pipe, an extra-heavy bend having the same capacity as a bend made from standard-weight pipe. This is true, however, only in

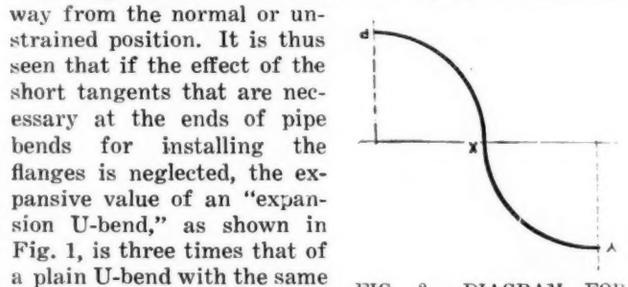


FIG. 2. DIAGRAM FOR EXPANSION U-BEND ANALYSIS

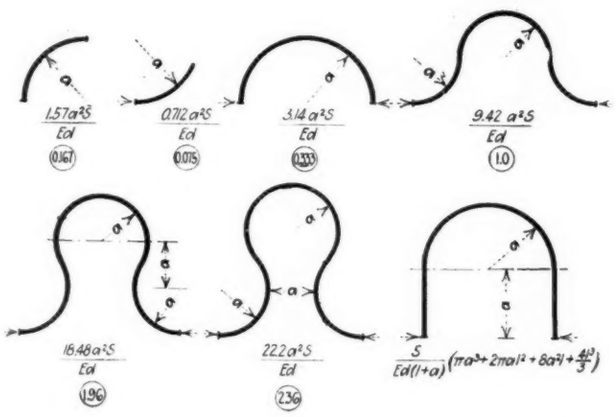


FIG. 3. "ALLOWABLE EXPANSION" DIAGRAM FOR VARIOUS TYPES OF BENDS

case the effect of the internal steam pressure is neglected. For bends composed entirely of circular arcs the allowable deflection is proportional to the square of the radius for a given maximum fiber stress.

The expansive value of a quarter-bend depends upon how it is installed in the line. If the quarter-bend is installed so that the expansion of the line is applied in a way similar to that on one-half the U-bend already

considered, then its expansive value will be equal to one-half that of a U-bend having the same radius. If, however, the quarter-bend is installed in the reverse manner, so that the expansion of the line is applied similarly to that on the outer portion of an expansion U-bend, its expansive value will be reduced to a little less than one-fourth that of a plain U-bend having an equal radius.

In order to derive an expression for a double-offset expansion bend, it is necessary first to establish the form of the bend by locating the various centers of

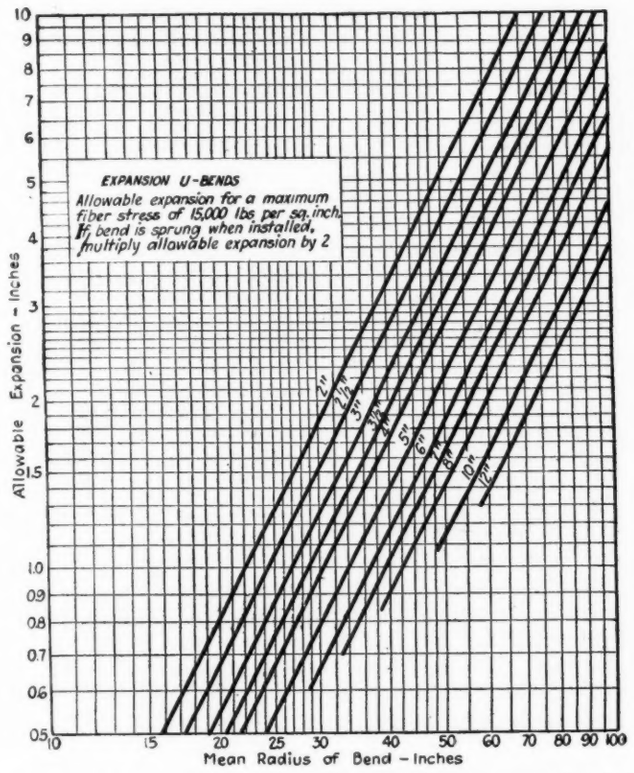


FIG. 1. EXPANSION CHART FOR EXPANSION U-BENDS OF COMMERCIAL STEEL PIPE, NOMINAL DIAMETERS 2 IN. TO 12 IN. INCLUSIVE

curvature. Fig. 3 shows two forms of double-offset bends with the corresponding deflection formulas.

The theoretical values for D as previously derived do not take into account the straight compression, or tension, as the case may be, in the bends due to the force P exerted by the pipe line. This additional fiber stress is small, however, and may safely be neglected. It is greatest in bends of minimum radius and amounts to about 630 lb. per square inch in a 6-in. standard-weight U-bend with 30-in. radius, when the maximum fiber stress due to bending alone is 15,000 lb. per square inch. For a plain U-bend the thrust equals $\frac{2SI}{ad}$ lb., and for a quarter-bend the thrust is the same. For an expansion U-bend the thrust is only one-half that on a plain U-bend or quarter-bend having the same radius and maximum fiber stress. This expression will be found convenient for checking up the design of anchors and fastenings in pipe lines where expansion bends are used.

The foregoing discussion also neglects the effect of the short tangents necessary at the ends of the bends for placing flanges and does not consider the increased length of U-bends and quarter-bends when connected in a line by the use of cast elbows. Values obtained by use of the formulas given will therefore be on the safe side, and this margin of safety may well be used to offset the effect of the restraining action of the line on either side of the bend. Care should be exercised in the location of anchors, so that the line will not restrain the proper deflection of the bend more than necessary. Anchors should be placed midway between bends where possible and not at points adjoining the bend.

All the foregoing bends may be used to take twice the expansion shown by springing the bend in the direction opposite to the expansion of the line at the time of installation. If this is to be done, the piping plan should bear a note stating the amount the bend is to be sprung, as the average pipefitter cannot be expected to know how much expansion the bend will take.

The formulas for the different bends are given in convenient form in Fig. 3, the expansion being one way from the normal or unstrained position. From Fig. 4 the allowable expansion[1] for any of the bends shown can be obtained by using the relative value factors shown in Fig. 3.

Lubricating Oils for Internal-Combustion Engines

BY FREDERIC H. GARNER

In the choice of lubricating oils for the internal-combustion engine the character of the oil used is mainly determined by the high temperatures produced in the cylinders by the combustion of the fuel; it is necessary that no marked decomposition of the oil shall occur to form carbon deposits which will interfere with the smooth and efficient operation of the engine. Minimum carbonization of the oil must therefore take place in the cylinders, and on the other hand, the oil must reduce friction as far as possible and remain in effective service for a long time.

LUBRICATING OIL TESTS

The nature of the oil used for lubrication depends on certain features of the engine, such as the method of cooling, engine speed and the clearances of the engine, and accordingly, oils of different physical properties, varying in viscosity and flash point, are required for the many types of engines. Certain qualities, however, should be possessed by such oils to insure that the engine will continue in serviceable operation without the necessity of frequent overhauling on account of carbon deposits and excessive wear. It is on this account that tests other than those ordinarily made on oils for the lubrication of machinery operating at ordinary temperatures are necessary to discriminate between various oils intended for the lubrication of internal-combustion engines.

These special laboratory tests have been devised in order to avoid the necessity of carrying out prolonged and expensive engine tests. Naturally, it is of the greatest importance to insure that the results of these laboratory tests do actually correspond with the results obtained when the same lubricating oils are tried out

[1]The various values of "allowable expansion" were determined by use of the expression:

$$Expansion = 3\pi a^2 S/Ed = 0.00487 a^2 d.$$

The allowable expansion shown is the deflection in one direction from the unstrained position of the bend, corresponding to a maximum fiber stress of 15,000 lb. per sq.in., provided the bend is not restrained in its movement.

on engines; unfortunately, many difficulties arise in carrying out such tests on a sufficiently large scale to determine definitely the relative merits of various oils, since apparently minor factors in the operation of the tests may exert far greater influence on the results than is produced by changing the lubricating oil.

The special laboratory tests used for this purpose are: (1) Evaporation loss; (2) carbonization test; (3) carbon content.

The evaporation loss and carbonization test are carried out by heating a weighed quantity of the oil to a high temperature (300-550 deg. F.) for a definite length of time; from the difference in weight the evaporation loss is readily calculated. The amount of asphalt material or tar in the oil left after evaporation is determined, and this gives the amount of carbonization. It is necessary to carry out this evaporation and carbonization test using special apparatus, and many precautions have to be taken to obtain consistent results. The apparatus and method of Waters for determining carbonization are probably most widely used at the present time. The carbon content is the carbon or coke left on distilling the lubricating oil in the absence of air. Conradson's apparatus is usually employed in this country for the determination of the carbon content of oils.

The evaporation loss indicates to a certain extent the consumption of oil that will take place in an engine provided the oil is of suitable viscosity.

Carbonization Test

The carbonization test is valuable because it indicates the decomposition that takes place on the cylinder head and at other places in the engine where the oil is exposed in the form of a thin film to the high temperature. The carbon content of the oil is not the actual amount of carbon present in the oil, but is the amount of coke or carbon left when the oil is heated in the absence of air. The importance of this test is apparent when it is realized that the lubricating oil in the cylinder comes into contact with the combustion flame or very hot surfaces and is immediately vaporized, leaving, however, a small amount of carbon behind. The following table gives a summary of the average temperatures for various parts of internal-combustion engines; of course the temperatures vary to a great extent according to the type of engine and the speed at which it is run.

Part	Temperature, Deg. F.	
	Gas Engine	Gasoline Engine
Maximum temperature of gas	2,730	3,000–3,350
Piston center of face	750	750
Center of exhaust valve	750	1,300–1,400
Center of inlet valve	480	....
Cylinder head	212–480	400–450
Crankcase	....	100–230

The suction stroke (in the four-stroke cycle) is the only stroke in which there is a smaller pressure in the combustion chamber than in the crankcase, and therefore, during this stroke leakage of lubricating oil into the cylinder may take place. The extent of this leakage is dependent on the efficiency of the piston seal; that is, on the effectiveness of the piston rings. It is from this oil, drawn past the piston rings by the suction and exposed to the high temperatures of the cylinder, that carbon deposits are formed.

Some of the oil will settle on the piston and cylinder heads and will carbonize more or less rapidly according to the nature of the oil; asphaltic material which forms from the oil decomposes, giving carbon. There is, of course, present on the cylinder walls an oil film which is constantly renewed; this film is probably only slightly affected by the heat of combustion, as the temperature of the cylinder wall is comparatively low, and therefore no appreciable carbonization will take place.

However, the major part of the oil getting into the combustion space is probably present as a fine spray. The heat of explosion may be sufficient to burn completely the smaller droplets, but the larger ones will be only partly burned by the momentary high temperature of the explosion. Thus carbon and asphaltic material are formed from the oil. If the carbon so formed is light in texture, it will be blown out of the exhaust in the same way as the carbon produced from the fuel when too rich a mixture of fuel in air is used; if, however, dense asphaltic material is formed, in the ensuing compression stroke it will tend to adhere to the piston head and cylinder walls, giving rise to carbon deposits. The carbon deposits in an engine, as is well known, do not consist wholly of carbon, but always contain some asphalt and also metallic particles derived from water in the engine. In the other three strokes of the cycle, where greater pressure is present in the cylinder than in the crankcase, the carbon mixed with oil is forced past the piston rings into the crankcase, giving the characteristic black appearance of used oils.

The Suction Stroke the Most Important of the Whole Cycle

According to the views here presented, the suction stroke is the most important of the whole cycle, from the point of view of lubrication; the leakage of oil occurring during this stroke is the origin of the carbon deposits found in engines and is also responsible for the total consumption of the oil in the engine. As it is upon the oil spray in the combustion space rather than upon the oil film on the walls that this carbon formation is mainly dependent, the rapid carbonization of oil (that is, the carbon content) will be a more important factor in the testing of lubricating oils for internal-combustion engines than the gradual carbonization at lower temperatures. The consumption of oil in the engine is also more dependent on the viscosity of the oil used than upon its fire test or flash point.

In lubricating oils there are present small amounts of compounds of a resinous character, and as a result of experimental work it has been shown that the extent of carbonization at high temperatures and the carbon content depend to a great extent on the amount of these resins present. These compounds decompose more readily than the hydrocarbons in the lubricating oils. At the same time it must be recognized that the hydrocarbons in lubricating oil also decompose, giving resinous compounds when exposed to air at high temperatures.

Thus carbon is formed from a lubricating oil both as a result of rapid vaporization of the oil at high temperatures and of the more gradual decomposition of the oil at lower temperatures. These processes take place simultaneously in the internal-combustion engine, and from the results of engine and laboratory tests it appears that the first process, rapid carbonization, is mainly responsible for the formation of carbon deposits and the engine troubles dependent thereon.

The cost of fuel and purchase of power for all the industries in the United States amounts to only about 2½ per cent of the value of the products and is only about 4½ per cent of the value of the materials going into these products.

Burning Powdered Coal

By F. R. LOW

IMAGINE a particle of carbon $\frac{1}{100}$ of an inch in diameter. In burning down to one-half that diameter, or 0.005 of an inch, it will burn up $\frac{7}{8}$ of its weight, because the volume is as the cube of the diameter and the cube of $\frac{1}{2}$ is $\frac{1}{8}$. There will therefore be only $\frac{1}{8}$ of the volume or weight left in the 0.005-in. sphere.

In burning down to one-half its diameter, it will make CO_2 and nitrogen enough to make a spherical envelope around itself about 0.4 of an inch in diameter.

So here you have this particle reduced by combustion to one-half it diameter and one-eighth of its weight being wafted through the furnace surrounded by an atmosphere of non-combustible gases over 80 times its own diameter.

Starting with a $\frac{1}{100}$-in. particle, the volumes of CO_2 and nitrogen, the diameters of the spheres that this gas would make and the ratio of the diameter of the particle still unburned to the diameter of the gaseous sphere surrounding it are as follows:

Diameter	Volume Cubic Inches $V = \frac{\pi d^3}{6} = 0.5236 d^3$	Weight Lb. $\frac{80\ V}{1728}$	Weight Consumed in Burning from 0.01 In. Diameter to Other Diameters	Gas Generated, Cu.In. Col. 4 × 1,644,486	Diameter of Gas Sphere $d = \sqrt[3]{\frac{6V}{\pi}}$	Ratio of Diameter of Gas Envelope to that of Unconsumed Particle
0.010	5,236,000 × 10⁻¹³	2,424,079 × 10⁻¹⁴				
0.009	3,817,043 × 10⁻¹³	1,767,333 × 10⁻¹⁴	656,746 × 10⁻¹⁴	0.010800	0.27425	30
0.008	2,680,832 × 10⁻¹³	1,241,286 × 10⁻¹⁴	1,182,793 × 10⁻¹⁴	0.019451	0.33367	42
0.007	1,795,900 × 10⁻¹³	831,437 × 10⁻¹⁴	1,592,642 × 10⁻¹⁴	0.026190	0.03845	53
0.006	1,130,979 × 10⁻¹³	523,603 × 10⁻¹⁴	1,900,476 × 10⁻¹⁴	0.031253	0.039081	65
0.005	654,500 × 10⁻¹³	303,010 × 10⁻¹⁴	2,121,069 × 10⁻¹⁴	0.034880	0.40538	81
0.004	335,104 × 10⁻¹³	155,141 × 10⁻¹⁴	2,268,938 × 10⁻¹⁴	0.037312	0.031459	104
0.003	141,372 × 10⁻¹³	65,450 × 10⁻¹⁴	2,358,629 × 10⁻¹⁴	0.038787	0.41998	140
0.002	41,888 × 10⁻¹³	19,393 × 10⁻¹⁴	2,404,686 × 10⁻¹⁴	0.039544	0.42269	211
0.001	5,236 × 10⁻¹³	2,424 × 10⁻¹⁴	2,421,655 × 10⁻¹⁴	0.039823	0.42369	424

There are probably two thoughts in your minds. One one-hundredth of an inch is too coarse for powdered coal—and the non-combustible gas does not remain in a symmetrical spherical atmosphere around each particle.

So far as the first thought is concerned, what I have said of the $\frac{1}{100}$-in. particle is just as true of a particle of any size. Let the sphere be one-millionth of an inch or a million miles in diameter, if it were reduced by combustion to one-half of that diameter it would lose $\frac{7}{8}$ of its weight and generate enough CO_2 and nitrogen to make a sphere having a diameter over 80 times its own reduced diameter.

Coal for burning in the pulverized form is commonly reduced so that 80 per cent of it will pass through a sieve with 200 meshes to the inch. One two-hundredth of an inch is 0.005. Let us do even better and take 0.004. The volume of a particle 0.004 in. in diameter is shown in column 2 to be 335,104 ten-trillionths of a cubic inch. Its volume when it has burned to one-half of that diameter, or 0.002 in., is seen to be $\frac{1}{8}$ of 335,104 = 41,888 ten-trillionths. The weights in the next column are of course in the same proportion

$$\frac{19{,}393}{155{,}141} = \frac{1}{8}.$$

So that, whatever the size of the particle may be to start with, when it has burned down to one-half its diameter it will still have $\frac{1}{8}$ of the original fuel value and have to get rid of an atmosphere of smothering non-combustible gases of some $80^3 = 512{,}000$ times its own volume to be as free to meet with oxygen as it was in the beginning.

One two-hundredth of an inch, $\frac{19{,}393}{100{,}000{,}000{,}000{,}000}$ of a pound—rather a small quantity, but containing some potency for combustion—quite some few carbon atoms yet. How many do you suppose? Several thousand? Write 166 for a numerator and 1 with 26 ciphers after it for the denominator and you have the expression for the weight of an atom of hydrogen in grams. Millikan gives it as 1.662×10^{-24} and says it is right within ± 0.002. Taking the weight of the carbon atom as 12 times that of the hydrogen, and one gram as equal to 0.00220462 lb., I compute that there are $\frac{10^{27}}{44}$ atoms in a pound of carbon.

The little particle of carbon 0.002 in. in diameter weighs $\frac{19{,}393}{10^{14}}$ lb. It would therefore, if my figures are correct, still contain $\frac{19{,}393 \times 10^{27}}{10^{14} \times 44} = 4{,}410{,}000{,}000{,}000{,}000$ atoms of carbon, each of which must meet and combine with two atoms of oxygen if the combustion is to be complete.

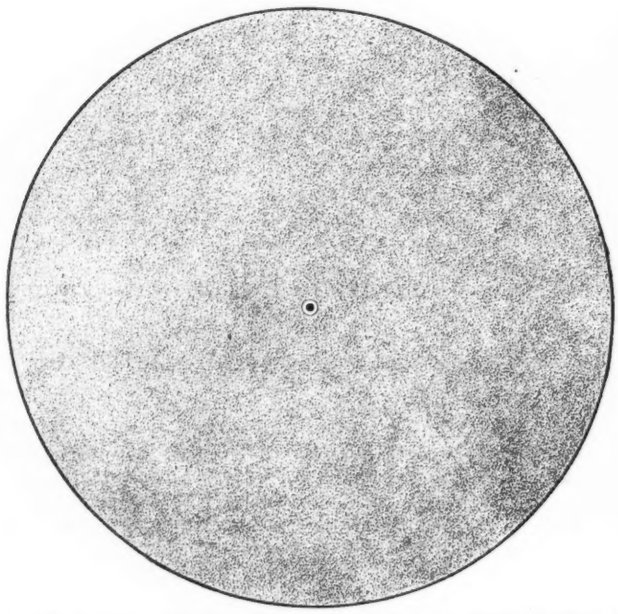
How much time has it taken to do this in? Suppose a pound of carbon makes 1,500 cu.ft. of gas at the furnace temperature, and that there is a cubic foot of furnace volume per pound of coal burned per hour. The 1,500 cu.ft. of gas generated by the combustion of one pound of carbon per hour would be generated at the rate of $\frac{1{,}500}{3{,}600} = \frac{5}{12}$ cu.ft. per sec., and $\frac{5}{12}$ cu.ft. would require $1 \div \frac{5}{12} = 2.4$ seconds to pass through a space of one cubic foot.

This is from the time it started. When the 0.004-in. particle was injected into the furnace, it had 38,280,000,000,000,000 atoms of carbon in it, each of which had to meet and combine with two atoms of oxygen if the particle was to be completely burned.

And they had to get at these atoms of oxygen through an atmosphere of non-combustible gases created by their own combustion.

Of course the situation is saved by the fact that if they cannot get two atoms of oxygen, they will combine with one and become carbon monoxide, in which

gaseous form they can be swept out into the vortex of flame and stand a better chance of finding the other oxygen atom, but this conception of their sizes and number and of the shortness of the time available for the complicated process which they must undergo throws some light upon the difficulties with which those who have been dealing with the problems of burning pulverized coal have encountered. It is evident that there must be a large furnace volume. It is evident that these floating particles must have an atmosphere rich in oxygen, diluted as it is by the products of their own combustion, if they are to be completely burned, and that striving for too high a percentage of CO_2 may result in sending off carbon unburned even to CO. It is not



ATMOSPHERE OF NONCOMBUSTIBLE GAS SURROUNDING PARTICLE OF PULVERIZED COAL WHEN HALF BURNED

surprising that they cannot find in the slag and in the dust of the back connection enough residue to account for the ash that they know is in the coal.

The rate at which a particle will settle decreases very fast as its size decreases. For particles of gold 0.001 of a millimeter in diameter the rate of the fall in water would be 2.4 millimeters per minute, but with gold particles 0.00001 mm. in diameter the rate of settling is about 10 millimeters per month. When the particles are fine enough, something below 0.004 min. in diameter, they take on, under favorable conditions, a movement among themselves, as may be seen under an ultra microscope, and remain in suspension indefinitely like oil in an emulsion or the graphite particles in Oildag or Aquedag.

The best explanation that has been offered of them is that they are due to the unequal impact of the molecules of the surrounding fluid upon opposite sides of particles so small that the law of averages which keeps the impact upon all sides of larger bodies substantially equal no longer holds. It is quite possible that a large proportion of the non-combustible in the fuel is carried off in so finely divided a state that it floats away to be brought down by the rain long afterward and far away from the spot where its associated carbon was burned.

Electric Steam Generation*

The sulphite and paper mill at Wargön, Sweden,[1] was a few years ago swept by a fire which entirely destroyed the steam plant, and as a plentiful supply of electric energy was available at a low figure, it was decided to replace the old fuel-heated steam boilers with electric. This plant, probably the largest one of its kind, has been in use for about a year and embraces seven boilers, each of 2,000 kw. input capacity, designed for a steam pressure of 12 kilos per square centimeter (170 lb. per sq.in.) with a three-phase alternating current of 10,000 volts.

When It Is Economical to Use Electric Energy for Steam Generation

Owing to the fact that interest in the electric generation of steam has greatly increased in the last few years, it may be well to state that although it proved economical in this case to change over to electric steam generating, it is as a rule only economical to use electric energy for this purpose either because of its cheapness or when excess power is available. For instance, in works having their own power plant and also where electric energy is paid for on a per-kilowatt-year basis, it often occurs that a great deal of the available energy is not utilized, because the power consumption in the plant is exceedingly variable. Furthermore, it often happens in large electric-power plants that during certain times of the day when the power consumption is less than usual, there is a great deal of electric energy to spare. Attempts have been made to store the energy in the water basin by regulating the water supply, but it is seldom possible to utilize all the existing power in this manner. By transforming all the excess power into steam, a new method is found to make use of all the energy available, and for works that are in need of steam for boiling and drying purposes or heating this method is most advantageous.

Electric Boilers Classified

Electric boilers can be classified in two groups, those equipped with resistance elements and those equipped with electrodes. Boilers equipped with resistance elements are again of two kinds. In one of these the elements are open and placed inside the water space, the current passing not only through the resistance elements, but also through the water, so that the elements may be made smaller than in the other type hereinafter described.

In boilers where the elements are placed open in the water, alternating current only can be used, as the water otherwise decomposes. If direct current is preferred, it is necessary that the resistance elements be kept from direct contact with the water. There are several designs of such boilers made, the one most used for heating purposes and the like having tubes within which the resistance elements are placed. Of course these boilers may also be used for alternating current.

The advantage of this kind of resistance boilers is in the ease with which the elements may be inspected and replaced without interruption to service. Boilers equipped with resistance elements are suitable only for tensions up to about 800 volts.

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*Articles descriptive of electric steam-generating plants in Switzerland and France were published rspectively in the Oct. 12, 1920, and March 8, 1921, issues of *Power*.

[1]Notice of the rebuilding of this plant and adoption of electricity for steam generation was published in the Sept. 14, 1920 issue of *Power*.

We now come to the other large group of electric boilers; namely, those equipped with electrodes and adapted for alternating current only, but on the other hand for low as well as for high tensions, up to, say, 20,000 volts. The construction of boilers for low or high tensions differs greatly. If only low tension is to be considered, the electrodes can, without complicated

FIG. 1. ELECTRIC-STEAM BOILER PLANT AT WARGON, SWEDEN, SHOWING SIX OF THE 2,000-KW. UNITS

construction details, be placed directly in the water, as its resistance is sufficient to prevent short-circuiting.

If, on the other hand, the boilers are intended for high tension, it is necessary to impede the current in some way in its path through the water. This is often done by surrounding the electrodes with porcelain pipes open in the ends and dimensioned to suit the conductive capacity of the water and the size for which the apparatus is constructed.

Regulation of the Load

Regulation of the load in electric steam boilers has two objects—one to produce the steam as needed, and the other to take care of the excess power for utilizing all the electric energy available at all times. There are several methods; on boilers furnished with several groups of electrodes the most simple way is to switch on or off a number of the groups. In boilers intended for low pressure and with bare electrodes the load may be varied by increasing or reducing the contact area of the electrodes in relation to the water, either by raising or sinking them, or by raising or lowering the surface of the water. In certain designs the load is altered by changing the distance between the electrodes.

One of the difficulties in constructing electric boilers has been to design the leading-through tubes of the electrodes so that they will remain perfectly tight. In this respect it may be stated that boilers having stationary inclosed electrodes are superior to those in which the electrodes can be raised and lowered.

A method of regulation largely used is based upon varying the conductivity of the water. While the conductivity of ordinary sweet water is very small, after it has been allowed partly to evaporate the solids in solution are proportionately increased, whereby the conductivity is increased in a proportionate degree. If, therefore, boiler water is stored in a special tank, the resistance of the boiler water may be changed by feeding water from the tank or fresh-water supply, as it is desired to increase or decrease the boiler load. This method is simple and requires only small exchanges of water to effect a large variation of load.

High Efficiency of Electric Steam Boilers

The efficiency of the best electric steam boilers is generally very high, 96 per cent or more, to some extent naturally dependent on the insulation. The size varies from a few kilowatts to units of 6,000 kw., the latter corresponding to fuel-heated steam boilers having a heating surface of about 400 square meters (4,300 square feet.

Electric steam boilers have many advantages over those fuel-heated. Simplicity of construction and ease of control reduce attendance costs to a minimum, and with unskilled labor normal steam production can be

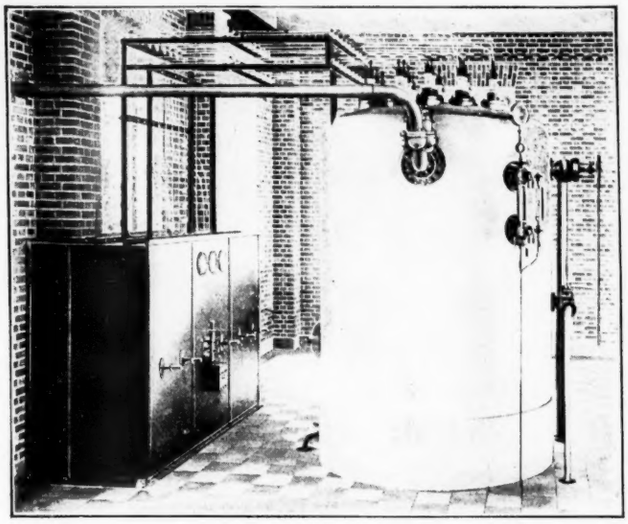


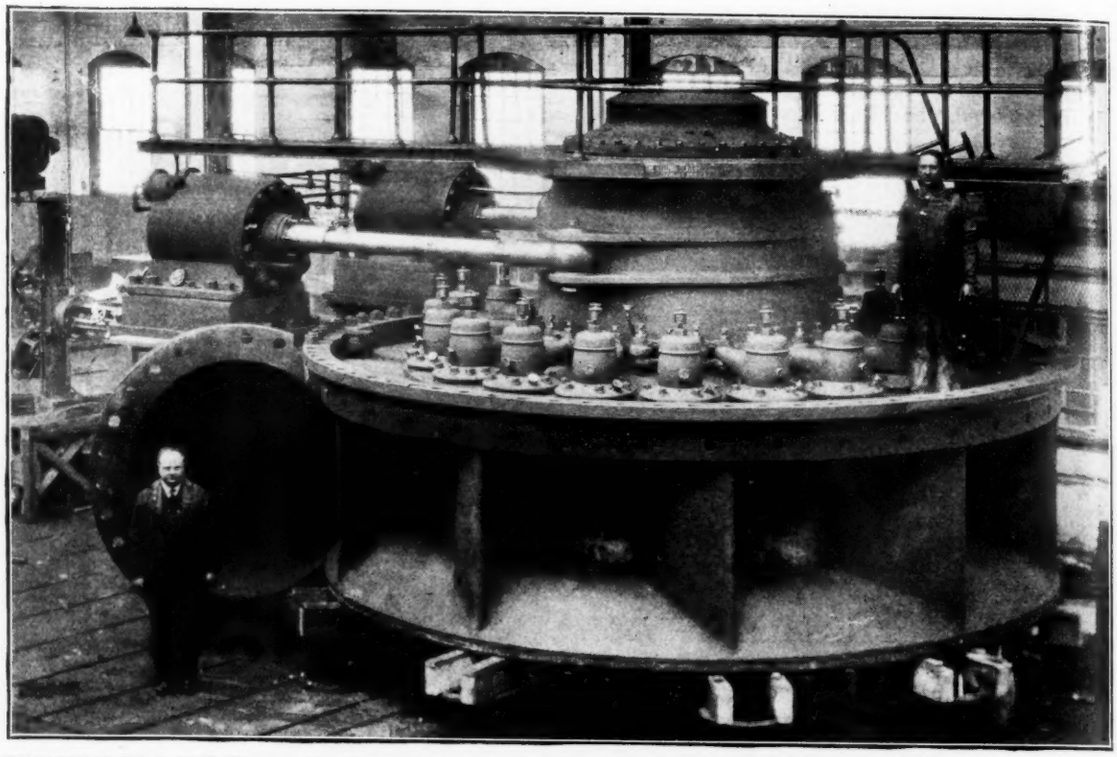
FIG. 2. ELECTRIC-STEAM BOILER IN THE WOOD-PULP WORKS AT SKOGHALLS-VERKEN, SWEDEN

maintained continuously with uniform pressure and with danger of explosion through "boiling dry" practically eliminated. Steam pressure can be worked up very fast, in some instances in as short a time as ten minutes after the boilers have been put under load.

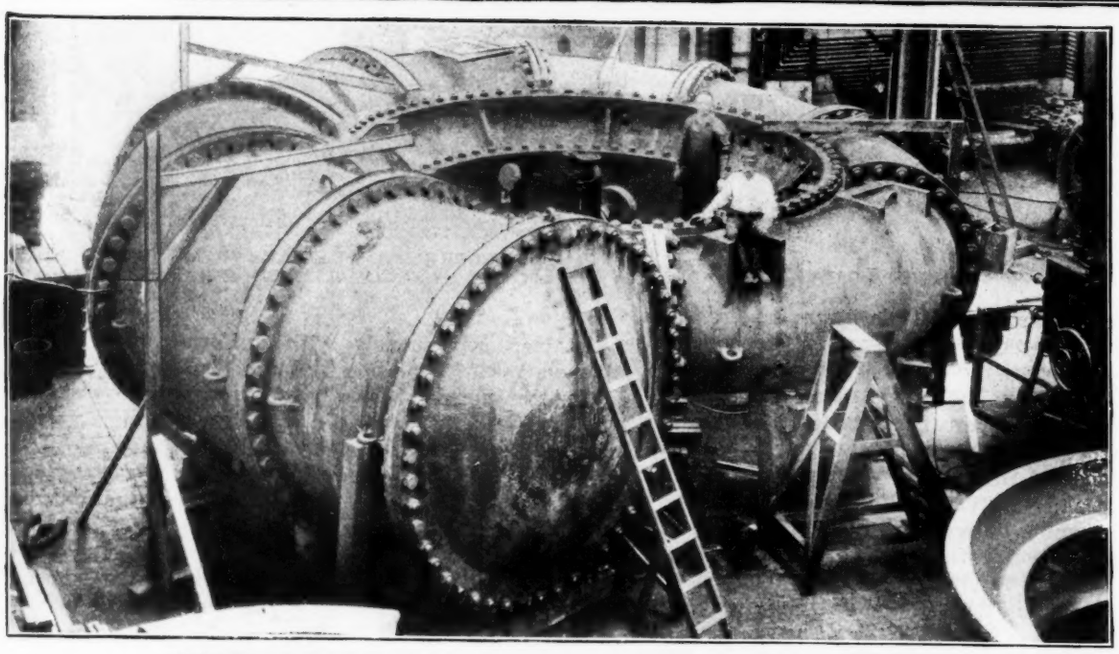
There is no formation of boiler scale because the ingredients of incrustation fall to the bottom in the shape of slime easily removed by blowing out.

In conclusion may be mentioned the reduction in the staff of "firemen" and the elimination of the cost of transportation and handling of coal and ashes.

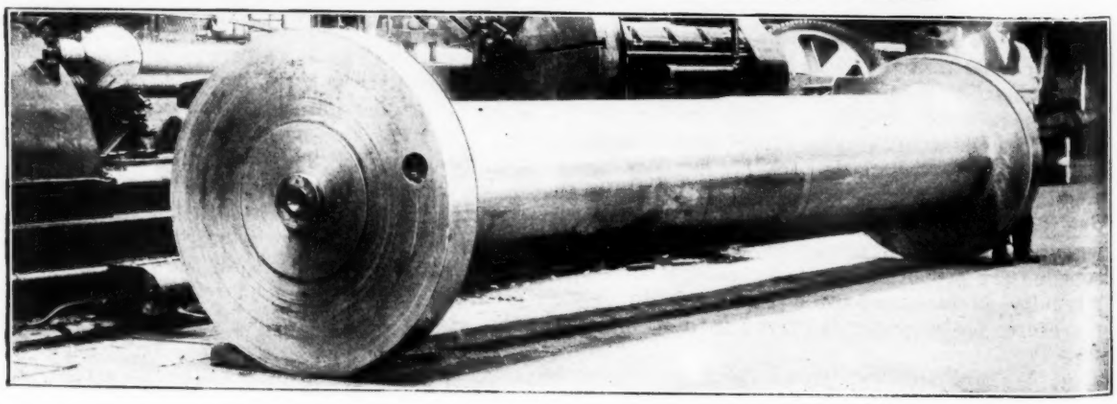
The Ohio Steam Boiler Inspection Law has been amended so as to permit boilers to be accepted in Ohio which have been inspected by inspectors holding certificates approved by the Board of Boiler Rules, and precluding the necessity of stamping the boilers "Ohio Standard." This will permit the inspection of boilers designed to be used in Ohio, but manufactured in other states, by inspectors in the cities of manufacture who hold certificates from the National Board of Boiler Rules, and will permit the acceptance of boilers in Ohio which are stamped with the symbol of the A.S.M.E. code.



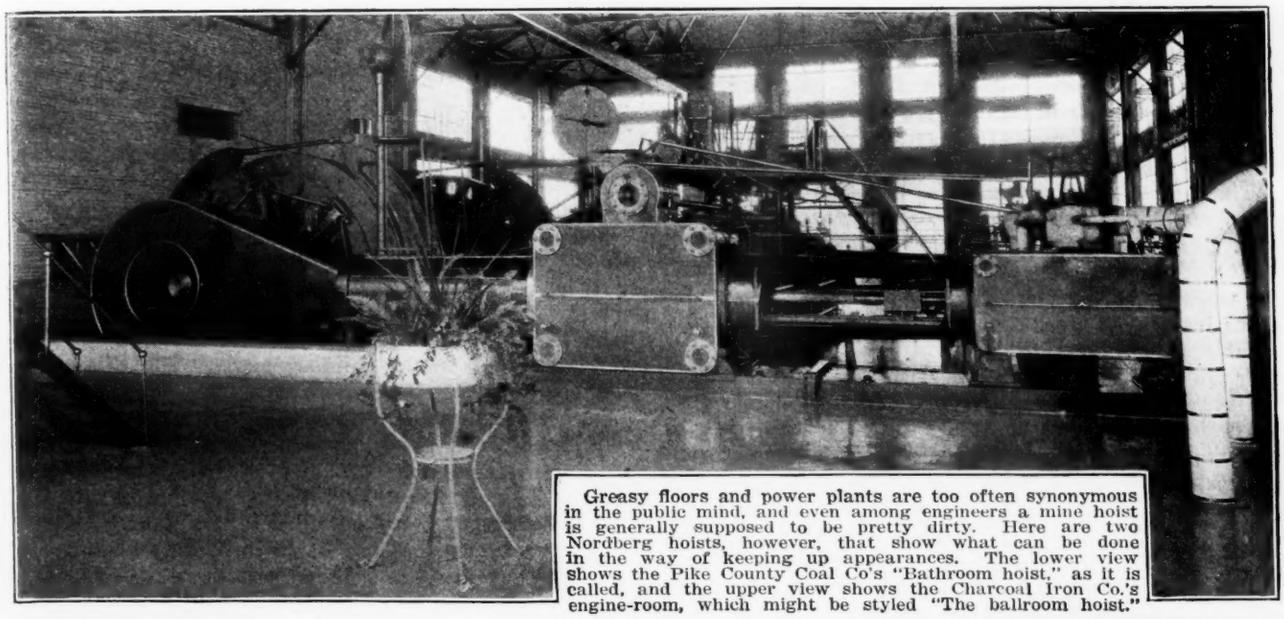
One of the Queenston turbines, the largest in capacity ever built. At normal rating it is to develop 55,000 hp. and at full gate 61,000 hp. It will operate under a head of 305 ft. and at a speed of 187.5 r.p.m. It is shown here erected in the Wellman-Seaver-Morgan shops prior to shipment.



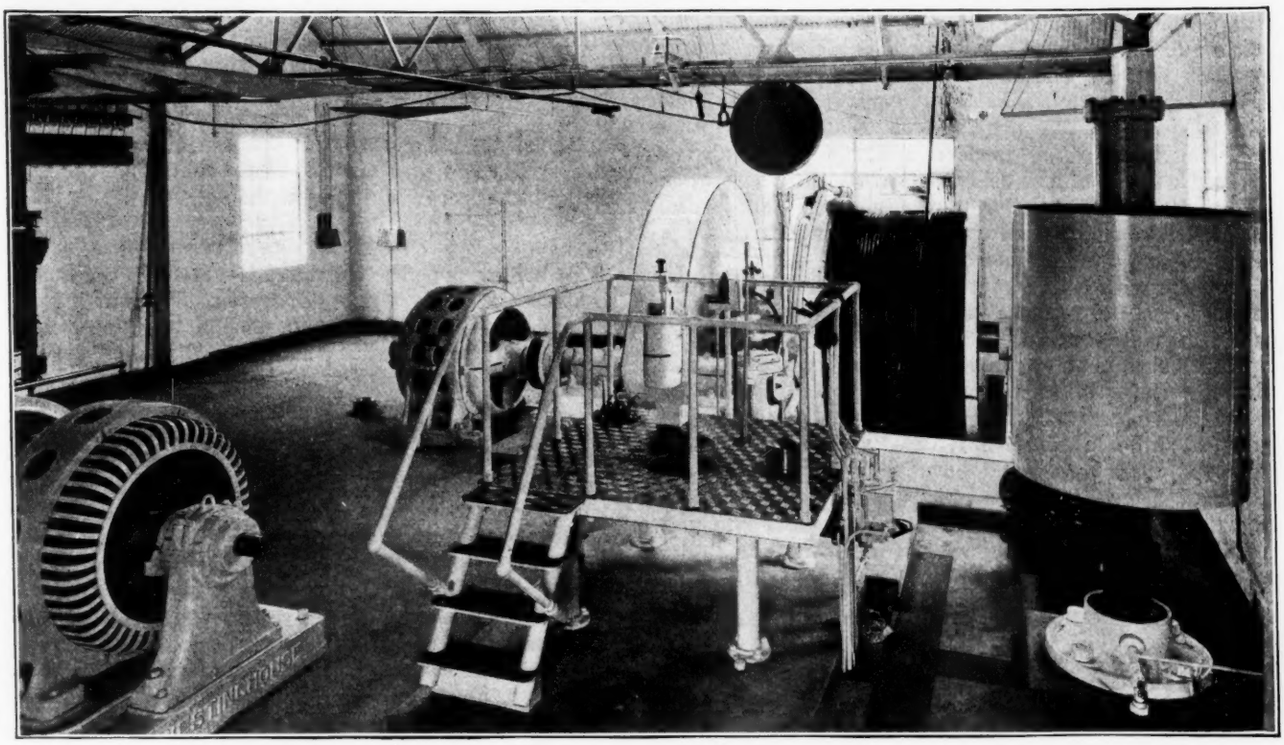
The cast-steel spiral casing for the Queenston turbine, under a pressure test of 260 lb. per sq. in. The casing is 2½ in. thick and 39 ft. across, and the inlet diameter is 10 ft. It is made in nine sections. The unit is being built for the Hydro-electric Power Commission, Canada.

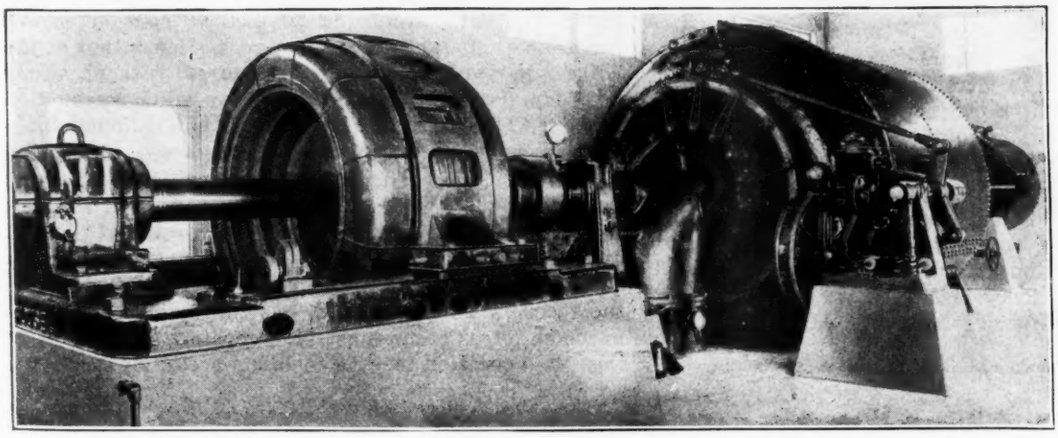


The main shaft for the Queenston turbine. It is 31 in. in diameter at the bearing and weighs 52,500 lb. An 8-in. hole is bored throughout its length. It was forged from a 72-in. ingot weighing 150,000 pounds.



Greasy floors and power plants are too often synonymous in the public mind, and even among engineers a mine hoist is generally supposed to be pretty dirty. Here are two Nordberg hoists, however, that show what can be done in the way of keeping up appearances. The lower view shows the Pike County Coal Co's "Bathroom hoist," as it is called, and the upper view shows the Charcoal Iron Co.'s engine-room, which might be styled "The ballroom hoist."





A water-turbine and induction generator at the San Joaquin Light and Power Corporation's No. 1-A power house, which is an automatic generating station located at a point where the open conduit line ends in a short drop to the forebay for the main No. 1 plant. A wood-stave pipe was built from the end of the open ditch line to this small turbine, the draft tube of which discharges into the main forebay. In this way a few feet of head were used.

Fuel Economy and the Human Factor

By Charles F. Wade*

It is a somewhat surprising fact that what the writer considers to be a most important point bearing upon the subject of economy in the use of fuel receives comparatively little attention in the various literature dealing with the problem.

The success that attends the adoption of new and improved appliances or methods of working depends to a great extent upon the knowledge and mental capacity of those whose duty it is to operate or control the working of the plant. There are many new appliances introduced from time to time that are potentially capable of giving vastly improved results in operation over the less up-to-date plant; yet they often fail to achieve the advantages claimed by their producers, owing to the inability of the operators to appreciate the principles upon which the apparatus works. These observations apply not only to the fireman, but in many instances to the man in a supervisory position.

Steam Production a Complex Scientific Problem

The various branches of science involved in a complete study of the principles of efficient steam generation prevent the factory engineer from mastering the whole subject in such a manner that all rule-of-thumb methods will be eliminated. His manifold duties in day-to-day operation take up too much time to allow him to study the chemical and physical questions that form the basis of all modern methods of economical combustion of fuel and utilization of the heat produced.

The fact must be thoroughly realized that steam production can hardly be classed as engineering, but is more properly the province of the chemist and physicist. A scientist with a fair knowledge of engineering would be more likely to produce efficient results than an engineer with a limited scientific knowledge. It is safe to say that there is no appliance upon the market that can correctly claim to be foolproof in the sense that its satisfactory operation is entirely independent of the technical skill of the operator. To fulfill such a requirement the apparatus would have to be gifted with the power of determining the class of fuel being used at any time, rate of steam demand and other varying conditions. Technical knowledge is therefore indispensable, whatever type of plant is used.

Importance of Training

Whatever be the qualifications of the supervising engineer, the training of the fireman is of supreme importance, as, under modern conditions, these men are called upon more and more to work with their brains and less with their muscles. In order to get the best out of a reasonably intelligent fireman there are three essential requirements to be satisfied: (1) Training, (2) incentive, and (3) control apparatus. The training of the fireman is really a matter for combined action on the part of the educational authorities, the trade unions and the employers. A scheme of education in the elementary scientific principles of combustion, fuel and its nature, heat of combustion, transmission of heat, steam generation, moisture, superheat, etc., should be mutually agreed upon by the various sections interested, and a certificate of proficiency instituted for men who pass the course in a satisfactory manner. After a suitable lapse of time no man should be engaged as a fireman unless he is duly licensed.

The next item, incentive, is important in that it touches upon the question of human nature as found in all ranks of life. With all the technical knowledge that can be imparted to any worker, it will be idle to expect the best results unless there is some tangible incentive for him to do his best. It therefore becomes necessary to give the worker an incentive in the shape of a bonus for efficient operation, or payment "by results."

In order to give satisfaction to all concerned a bonus scheme must be fair alike to employer and employee, and this cannot be said of some of the systems at present in vogue. The most glaring example of fallacious bonus schemes is, to the expert, that based on the percentage of CO_2 in the chimney gases. The CO_2 bonus may operate fairly for a short time, but when the boiler-room crew find out how to juggle with it, it will probably be unfair to the employer. The CO_2 record is but one link in a complete chain, and there are circumstances under which its indications are no guide at all to the thermal efficiency being obtained in the plant.

Bonus schemes that are liable to operate unfairly to the employee are those based on the evaporation of steam per pound of fuel used, the amount of coal used per unit output of the factory, etc. The only fair all-round basis for a bonus system of payment is the overall efficiency of the steam-generating plant; but it is not often adopted owing to the extensive records required to carry out such a scheme successfully. The plant-efficiency bonus system takes into account all sources of waste that are under the control of the fireman and not merely chimney losses.

Use of Control Apparatus

This brings us to the third and last item on the list of essentials; that is, control apparatus. Without a comprehensive equipment of the proper appliances and instruments for indicating and recording the results effected and the conditions obtaining at all times, it is hopeless to expect anything but mediocre and irregular results in the way of efficiency. The best of workmen cannot work without tools, and this applies as much to the fireman as to any other class of worker. The shovel and slicebar, etc., are necessary to produce steam, but they cannot do it efficiently without any other aid. We ask for regular steam pressure, an invisible condition, and provide a gage so that this may be measured; we need a constant water level, and provide a water glass for the purpose. We now ask for certain conditions as to waste-gas temperatures and composition, degrees of superheat, feed-water temperature and so forth, all of which are no more visible than steam pressure, and it is impossible to know whether these conditions are being fulfilled without supplying the proper apparatus for the purpose. The output of the boilers in steam cannot be measured without water or steam-flow meters or the efficiency of combustion without CO_2 meters, the heat loss in the chimney without pyrometers and CO meters, and so on.

The efficiency bonus system needs all the apparatus suggested to carry it out successfully, as well as some sort of laboratory wherein the calorific value of the fuel and its ash content may be determined as well as the combustible content of the ash heap. Not only must the recovery be ascertained, but the various directions in which losses occur must be accurately determined so that the operation may be modified accordingly.

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EDITORIALS

The True Spirit of Engineering

A SECTION meeting of one of the national societies was devoted recently to a discussion of certain local production processes. The formal addresses were followed by an open discussion in which practical experiences of members were freely presented. Keen interest was shown in the subject, and toward the end of the discussion a guest requested permission to ask a question which probably related more to psychology than to engineering. He stated that in work for the Government he was frequently required to investigate the processes of some of the food-producing industries. At each plant visited he was told that this particular process was strictly a trade secret of their own and could be revealed only in the strictest confidence. At the next plant of a similar character the management would insist that their process was also strictly their own production and was therefore a trade secret. It often developed that the processes in the two plants were identical, yet each thought that he had a great secret all worked out by himself. In some other cases it was found that a new process had been worked out at great expense which, to the speaker's personal knowledge, had been in use for years in plants in other parts of the country. These manufacturers try to hide their processes from one another, yet any intelligent workman could learn their methods in a few weeks.

Electrical and mechanical engineers seem to take much pride in relating their achievements to one another, and they freely discuss their experiences, as was evidenced by the preceding discussion. The guest wanted to know what there was in the nature of the different professions and businesses that makes some of them so secretive even when their best interests would be served by greater publicity.

A prominent and successful manufacturer replied that he found that publicity paid. Fellow engineers were glad to know of his improvements and often materially assisted him in further developments by friendly criticism and suggestions. Although other manufacturers had frequently copied his methods, he had found that he always had later developments ready before his competitors had perfected their copies.

This remark led another member to quote from Kipling:

> They copied all they could follow,
> But they couldn't copy my mind,
> And I left them sweating and stealing,
> A year and a half behind.

A third member stated that the difference was probably due to the ethical principles of different professions and businesses. The early leaders in mechanical and electrical engineering were men of broad vision who had founded the national societies for the purpose of mutual co-operation to advance their respective arts and sciences. It had become a tradition in these societies to share their professional experiences and to tell others of their achievements. Advances in the art are much more rapid when each worker knows what others have done. Hence, every engineer should give his earnest support to his professional organization and should take an active part in its meetings and its activities even at some sacrifice to his personal convenience.

Such discussion as this suggests thoughtful consideration of what should be the true spirit of the engineering profession. It should be the idea embodied in the word "Service"—service to clients or employers, service to the public by the exercise of special professional skill, and service to fellow engineers by freely sharing professional experiences and by rendering help and advice whenever possible.

How About Secondary Air?

IN THE combustion of any fuel engineers make careful preparation for the control of the primary air supplied under the grates or around the oil or gas burners for the initial stages of combustion. All too frequently, however, equal care is not given to the proportioning of secondary air. Recently, a striking example of this situation was noted in a large natural-gas furnace installation.

In this case the primary air for combustion was being drawn in by the stack draft through openings surrounding the burner. The flame within the furnace impinged upon a refractory fire wall, and the products of combustion passed upward and over this wall into the main furnace chamber. At the top of the wall was the ideal point for the introduction of secondary air because at this point it was vital to control the combustion for effective heating throughout the furnace space. But this plant was operating without any provision for the introduction of secondary air and it was, therefore, necessary to draw in all the air needed through the openings adjoining the burner. The inefficiency of such an installation can readily be imagined.

The loss of heat in the products of combustion from a furnace operating with relatively high temperature in the flue products is amazing. Particularly for industrial-furnace operations which require high temperatures right up to the outlet of the furnace, these losses may reach fifty or sixty per cent even though the excess of air be reduced to the lowest possible amount. And if there is no control of the secondary air, a considerable excess of primary air is likely to result. Of course it is generally possible, in such circumstances, and often economical, to install a waste-heat boiler in order to utilize the heat in the flue products. But whether this is done or not is quite beside the point, if control of secondary air is not properly insured.

Some recent data made available by the Bureau of Standards bring out strikingly the unavoidable flue losses with high flue-product temperatures. At four hundred degrees with thirty per cent more air than theoretically required for combustion of the gas, which happens to be the minimum safe amount for the fuel used in this case, the flue losses are inevitably between

twelve and twenty per cent, according to the composition of the gas. At a thousand degrees these unavoidable losses from the furnace are about thirty-five per cent. At eighteen hundred degrees, a temperature commonly required in industrial heating operations, the losses are approximately sixty per cent. If an extra volume of surplus secondary air is permitted to enter the furnace, the losses become even greater than this, and one wonders whether any heating at this higher temperature could possibly be accomplished if there were such greater surplus of air.

With solid fuels and low temperature of flue products such as prevail in boiler plants, the same principles apply, though of course the magnitude of the loss is somewhat less appalling. However, the lesson for *any* installation is obvious. "Just enough and no more" certainly is a splendid maxim to guide here as elsewhere.

Burning Powdered Coal

IN THE last few years the use of powdered coal for fuel under boilers has made considerable progress. One of the essentials, a knowledge of which developed with systematic study of the subject, is large furnace volume. The fuel is being carried through the furnace, not as a gas volatilized from a stationary fuel bed and intimately mixed with the air necesasry for its combustion, but in a solid, though minute particle, in a current polluted by the products of its own combustion and that of its fellow particles. The necessity of large furnace volume, affording the particle time enough in passing through the furnace to be thoroughly consumed, is apparent when the process is analyzed, as it is in the article on page 745.

The article throws some light also upon the mystery that has always obtained with regard to where the ash goes in a powdered-coal boiler plant. With a coal having, by analysis, ten per cent of ash, there would be at least two hundred pounds of ash and slag to be accounted for for every ton of coal burned. No such amount is found, and although the difference must pass off up the chimney, nobody notices it even in the case of large installations. The article shows that the ash is probably reduced to such a degree of fineness that it floats indefinitely until washed out of the atmosphere by rain remote from its point of production.

Boiler-Room Development

THE article by Dr. Jacobus on "Boiler and Furnace Design" in this issue is, as might be expected from its *ex cathedra* nature, notable in more ways than one. In its logical and comprehensive discussion of the many details entering into the design of steam-generating apparatus, there is ample food for thought for the designing and operating engineer, as well as a solid basis for the conclusion that every plant must be weighed and judged in the light of its individual conditions.

Furthermore, the author's treatment of the subject emphasizes most interestingly the development that has taken place almost within the last decade or two, due to changing conditions in fuel production and transportation, in elements of boiler design and equipment which were almost "taken for granted" by old-school engineers.

It is not such a far cry to the time when brickwork in plenty, laid by a good mason, was all that was thought of, or for that matter all that was required, to provide a good boiler setting, and as for automatic stokers the pioneer salesman was liable to spend as much time convincing his "prospect" that a stoker was a good investment as that his was the best design and built on the demonstratedly best principles.

Increased pressures and temperatures have wrought a veritable revolution in that formerly dirty, neglected and generally unpopular interventing space between coal pile and engine room usually termed the "boiler house," and the specialist has come into his own, as in other branches of steam engineering.

A flow meter costs more than a shovel, but lasts longer and is a much more economical tool. The modern "fireman" is a man of brain, rather than brawn.

An Engineering Fallacy

WHILE the number of crankshaft failures in internal-combustion engines is by no means large, still an occasional breakage serves to keep alive the controversy as to the primary causes.

It is by no means unusual to hear engineers speak of a failure as being due to crystallization of the metal from bending stresses. Long ago the impossibility of such a service by crystallization was proved. Repeated experiments have revealed the fact that in a crankshaft that was forged and heat-treated without crystallization, no amount of bending in service will produce such a condition.

Investigation in all cases of crankshaft failure will reveal that the fault is always in worn bearings which cause the stresses in the unsupported shaft to exceed safe values. On another page appears an article dealing with two specific instances of low bearing which resulted in a failure of the shaft. Every engineer who has an engine of any description under his supervision should periodically examine the bearings. As long as the alignment of the crankshaft is maintained, no failure will happen save in those exceptional instances where heavy preignitions occur. In all cases the life of the crankshaft, as well as that of all other engine parts, depends on the care given it by the engineer.

Not many years ago, but before the Edison General Company and the Thomson-Houston Company swallowed each other, like the two snakes in the story, so that not even Wall Street could tell which from t'other, an engineer was placed in charge of a certain electric-light plant which was most decidedly and distinctly in the "lame duck" class. Its securities went begging on State Street, its books balanced red with sickening regularity, its "customers' list" was on the wane, and there was no money in the treasury. Furthermore, the plant was in wretched condition physically, and depended for its water supply upon the local "water works," which suffered from periodical shutdowns during which "juice" was not. Our engineer friend decided that the first and obvious step toward reconstruction was to provide water-storage tanks, but, without funds or credit, how? Some old tubular boilers, rusting in the scrap heap, set him thinking. A "lumper" was set to work removing what was left of the tubes, a small boy was sent to buy milk-can stoppers, which were later driven into the tube-holes from the inside, and—there were the tanks. Such opportunities for the exercise of ingenuity, while perhaps more apparent in the early days, are still present in many plants.

CORRESPONDENCE

Looking Out for Number One

The poem by Rufus T. Strohm on page 293 of the Feb. 22 issue of *Power* is clever and entertaining. I believe, however, that he is on the wrong track, and would suggest that the latter part of the poem, beginning with the words, "Perhaps you're right," should read as follows (the italics are my suggestions):

"Perhaps you're right," said Dave to me, "*and just as likely wrong, you see.* But I should worry and grow gray with troubles of a future day. I'll be beneath the sod, no doubt, before the oil supply runs out, and those who follow me *will know some better way to make things go.* I'm doing what a wise man would—*I'm up to date and making good.*"

The poetry is not so good, but I believe that the thought expressed is more correct. As far back as we have written records, each generation has worried about the next, while history reveals the fact that each succeeding generation has found some natural resource that was not previously available, and some method of using it. Good old Mother Earth has never yet disappointed industrious mankind, nor is there likelihood that she will in the future.

E. P. BAILEY
Treasurer, National Airoil Burner Co.
Philadelphia, Pa.

Chimney Felling Reduced to a Science

In the March 8, 1921, issue of *Power*, page 378, is an article describing the wrecking of four concrete-incased steel stacks for the Walworth Manufacturing Co., Kewanee, Ill. While the information given in regard to the concrete casing on these stacks is substantially correct, there are certain matters of importance pertaining to the cause of the failure of one of these stacks which should be more clearly understood.

The concrete casing was originally designed to be used for ordinary boiler service, producing temperatures of 500 or 600 deg. F. For this purpose the two or three years' service which the stacks had already given showed that the design had fulfilled the purpose intended. Had there been any expectation on the part of the designers that temperatures of three or four times those produced in ordinary boiler service would have occurred in the stacks, the design and construction would have been carried out in accordance with these extraordinary conditions.

Proof that very high temperatures were reached in these stacks is furnished by the fact that the firebrick with which the lower portions of the stacks were lined had spalled off with the fireclay with which they had been laid up. No testimony has yet been given that fixes the length of time during which the flame appeared at the top of the stacks. The fact is, however, that in changing the boilers over from coal to fuel oil difficulty was experienced in regulating the supply of air and oil so that considerable quantities of oil were blown through the boilers and accumulated in the stacks below the breeching. When the fires were pushed under the extreme overload condition under which the boilers were worked, this accumulated oil was ignited and the burning was so fierce as to cause the appearance of flame at the top of the stacks. This occurred at night, and no one knows how long this condition continued. However, experience with various types of furnaces used for testing purposes indicates that temperatures under like conditions to those to which these stacks were subjected, may rise to the neighborhood of 2,000 deg. F. within 15 or 20 minutes. The wonder is, therefore, that the stacks withstood this extraordinary treatment at all. Obviously, the original steel shell ceased to have anything to do with the strength of the stack long before this temperature was reached.

There is another point that is not brought out in the article. This concerns the heavy iron ladder attached to the top of the stack and firmly anchored to the concrete base. This ladder was on the outside of the stack and had no expansion joints in it. It is obvious, therefore, that when expansion took place, due to the enormous temperatures generated in the stack, this ladder was not heated to the same high temperature as the original steel stack, and consequently did not expand, and so acted to pull the stack out of plumb.

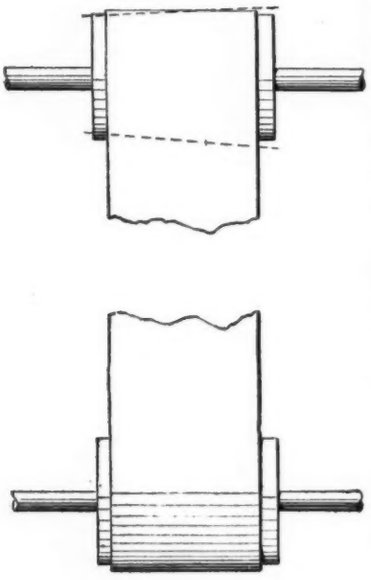
These additional facts are presented so that no erroneous conclusions will be drawn in regard to these chimneys. Every chimney builder or designer knows that temperatures such as those to which this stack at Kewanee was subjected require special attention, and that a special lining of some sort, preferably of firebrick, would be necessary.

The question might also arise as to the advisability of incasing steel stacks with concrete. Evidence is at hand that usually satisfactory results can be obtained by so doing and at a very reasonable cost. Considerable work of this sort has been done with the cement gun, without even putting the steel stack out of service. Numerous other successful examples are on record of inclosing steel stacks with concrete, by depositing concrete in forms in the usual manner. In this case the old steel stack is used as an inside form. Both of these methods of building a shell around the steel stack recommend themselves as economical.

F. BERGMANN.
Oak Park, Ill.

Why Belts "Run Up"

Will you please be kind enough to inform me why it is that belts run to the high side of the pulley? If my ideas are correct, in the case of a theoretically perfect belt running on two cylindrical pulleys with parallel axes, as shown in the accompanying sketch, the belt will run in one position indefinitely unless subjected to some external influence or unequal tension. If, however, one of these pulleys were even slightly larger in diameter on one side than on the other, as shown exaggerated by the dotted lines, it is, I suppose, an undoubted fact that the belt would move in the direction of the arrow and run off the pulley altogether. Now, we are taught that as a general proposition mechanical action takes place in the line of least resistance, and it would therefore seem easier and more logical for the belt to move in the direction opposite to the arrow, where the diameter of the pulley would be less, and consequently the belt tension would be less, and eventually run off the small end, which we know in practice is not the case. I am curious to know the scientific explanation of this. HARRY S. CURTIS.



BELT DIAGRAM

New York City.

[The attention of *Power* readers is invited to this query, which suggests a consideration of what would happen, and why, if the axes were placed at a slight angle, although in the same plane.—Editor.]

Misplaced Expansion Trap Responsible for Valve Failure

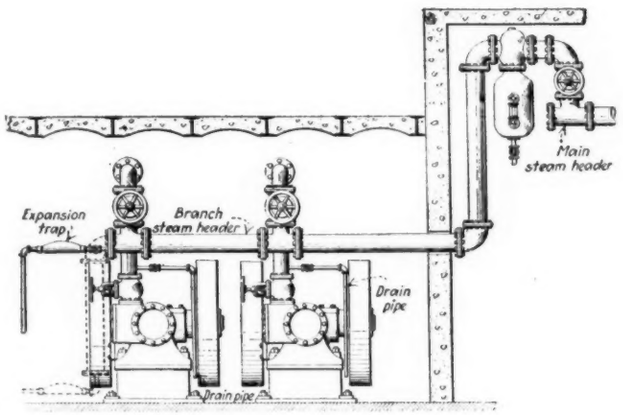
A pair of high-speed engines had been installed in a manufacturing plant. The steam piping of the engines was arranged as shown in the illustration. A branch header was run from the main header in the boiler room through a concrete wall into the engine room, and the steam supply for each engine was taken from this branch header. To keep down the expense of the job, steam separators were not installed in the supply pipes. Instead, a single separator was inserted in the branch header on the boiler-room side of the division wall, and an expansion trap was connected for draining that portion of the header extending into the engine room. A ¾-in. drain pipe was also connected to the steam-supply pipe of each engine at a point just above the throttle valve.

When the installation was complete, the engineer attempted to start one of the engines for a trial run. He opened the ¾-in. drain valve above the throttle and blew out the water of condensation that had collected in the vertical section of the pipe. He then opened the throttle valve about half a turn. Instantly, there was a jolt that shook the piping system, and the body of the throttle valve, which was of the globe pattern, was cracked wide open. The shower of water that issued from the broken valve proved conclusively that the accident was due to water hammer.

The engineer concluded that the horizontal part of the branch header in the engine room must have been at least half full of water, and that the steam rushing toward the partly opened throttle had carried a considerable portion of this water along with it. He attributed the absence of water hammer when he had previously opened the ¾-in. drain valve to the fact that the velocity of the steam flowing toward the small valve orifice was not sufficient to disturb the mass of water lying in the header pipe.

At any rate it all indicated that the expansion trap, as connected, was not a proper device for draining the branch header, and this through no delinquency on the part of the trap itself. The trap worked faithfully according to the principle upon which it was designed to work, but the principle was inadequate for the service requirements. The trap was simply misplaced through failure of the man who made the piping layout to recognize its limitations.

The steam pressure was 130 lb. per sq.in. The temperature of steam at this pressure is about 355 deg. F. The expansion trap was designed to open for the discharge of water at about 210 deg. and to close at 212 deg. F. But the header was insulated with an efficient magnesia covering, hence it took a long time for the water of condensation to cool down to the requisite 210 deg. Thus water at a temperature anywhere between 210 and 355 deg. was constantly accumulating, so that the branch header filled up.



PIPING FROM HEADER TO ENGINES SHOWING LOCATION OF EXPANSION TRAP

The owners of the plant were averse to incurring the expense of discarding the expansion trap and putting another type of trap in its place. So the engineer connected a drop-leg to the end of the branch header, as indicated by the dotted lines, and connected the expansion trap to the bottom of it.

With this arrangement the trap gives good service. The water in the bottom of the drop-leg, being remote from the high-temperature steam, becomes cool enough for the trap to operate when the leg still lacks several feet of being filled to the top. A. J. DIXON.

St. Louis, Mo.

Are Small Boiler Tubes Desirable?

The desirability of using small tubes in horizontal return-tubular boilers is brought up by N. S. Riggin in the Jan. 25 issue of *Power*. He points out a number of reasons why he thinks small tubes are objectional from a practical viewpoint. His reasoning is logical and one might possibly add to his list of objections. For example, a small tube will be likely to give trouble by sagging in a long boiler, because it is not stiff enough to support its own weight without excessive deflection. For this reason a 20-ft. boiler should have nothing less than 4-in. tubes, unless some method is used to support them.

There is also much to be said in favor of the larger tubes, when considering the care and repair of the boiler. The larger tubes are easier to clean, internally and externally. The gage, being thicker, corrosion, should it occur, will not reduce the tube walls so quickly. On the other hand, the large tube is probably harder to replace should that become necessary.

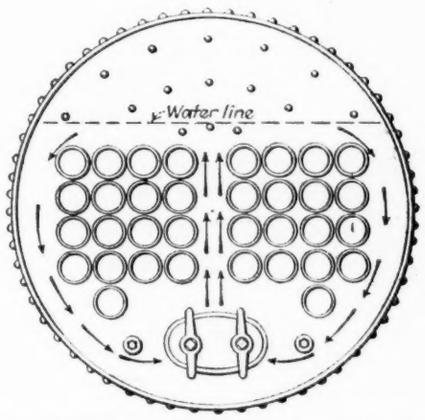
The matter of circulation, which Mr. Riggin mentions, deserves careful consideration. It is assumed that the designer, whether he is using either a small or a large tube, will not crowd the tubes so closely together in his attempt to increase the heating surface as to interfere seriously with circulation. Some designers are leaving wide spaces at the shell and in the middle of the tube bank to decrease the resistance at these points. The path of water circulation is supposed to follow the shell downward at the sides, and the two streams are supposed to join at the center in an upward direction, as shown in the sketch. It is doubtful whether the circulation may be made to follow the path indicated merely by reducing the resistance as shown, but the idea is not a bad one. The path of circulation in the horizontal return-tubular boiler is not defined as clearly as in many of the water-tube types, hence it is difficult to say what the effect of a few tubes more or less or a change in the tube diameter may have on circulation. In any event the designer must be conservative in arranging the tube spacing.

As to the water-storage capacity, steam space and disengaging area, the tendency is probably to reduce these somewhat. Water-tube boiler practice has impressed us with the fact that the ideal boiler would be the one which would hold a very small amount of water, if we might have some arrangement which would feed the water to the boiler at the same rate that the steam is drawn from it and also if we could control the rate of combustion to the demand on the boiler. The first of these requirements is met by that type of automatic feed-water regulator which adjusts the feed to the load. Since it is impossible for any automatic mechanical device to anticipate changes in the load, considerable water space is necessary in any boiler, although it has been relatively reduced in the modern water-tube type. Because of the fact that in the return-tubular boiler the path of circulation is not so well defined as in most water-tube boilers, it will not ordinarily respond as quickly to a change in the load; hence the water-storage space must be greater relatively than in the water-tube type.

The requirement with reference to furnace control may be met by automatic damper regulation, automatic fan control and intelligent operation, but here again, since the tubular boiler is more sluggish than the water tube, the operating conditions will not respond so flexibly. Simply the fact that we may use a tube of smaller diameter in one boiler than in another does not necessarily mean that we will have more water space in the boiler with the large tubes, although a slight reduction would not seem to be seriously objectionable.

Similar reasoning might be used in connection with the disengaging surface and steam space. In former days we required a steam dome or drum on every boiler, which practice seems to have gone out of style. A slight reduction of these items such as might be caused by the use of smaller tubes would scarcely have a noticeable effect on the operation of the boiler.

To see just what effect the use of different diameters of tubes might actually have on water-storage capacity, steam space, disengaging area and tube area, I have taken three tube layouts for a 72-in. x 18-ft. boiler as recommended by the Hartford Steam Boiler Inspection and Insurance Co. and have given the results in the accompanying table. With the 4-in. tube layout as a basis of comparison, I found that when using the 3½-in. tubes the total heating surface would be increased about 13½ per cent, the water space was increased about 4¾ per cent, and the steam space and disengaging area were decreased about 14¼ and 8 per cent respectively. The difference is even more marked when 3-in. tubes are used, as the heating surface is increased approximately 20 per cent, the water space increased 6¼ per cent and the steam space and disengaging area decreased about 14¼ and 8 per cent as before. The case against the small tube does not appear to be as serious as I had supposed.



SKETCH SHOWING PATH OF WATER CIRCULATION

COMPARISON OF VARIOUS FEATURES OF A 72-IN. BY 18-FT. HORIZONTAL RETURN-TUBULAR BOILER

Tubes No.	Tubes Size, In.	Heating Surface Sq. Ft.	Heating Surface Per Cent	Water Space Sq. Ft.	Water Space Per Cent	Steam Space Sq. Ft.	Steam Space Per Cent	Diseng. Area Sq. Ft.	Diseng. Area Per Cent	Tube Area Sq. Ft	Tube Area Per Cent
74	4	1488	....	288	....	105	....	99	....	5 65	....
98	3½	1690	+13½	302	+4¾	90	—14¼	91	—8	5 67	0
122	3	1786	+20	306	+6¼	90	—14¼	91	—8	5 15	—9

There is one more reason for investigating the small tube and that is the draft. I found, as tabulated, that the difference between the 4- and 3½-in. tubes was inappreciable and that the use of the 3-in. size reduced the tube area about 9 per cent. The draft resistance through the boiler will be increased with the smaller tubes to a greater extent than the difference in tube areas might seem to indicate. The draft resistance through the boiler will be less with the larger tubes, and when the available draft is restricted the small tubes may obstruct the gas passages to an objectionable

extent. With natural draft a higher stack will be required for the same boiler capacity if small tubes are used.

When it comes to the efficiency of the boiler in connection with the heat transfer, the story is somewhat different. This subject has been investigated by Messrs. Kreisinger and Ray, and the results have been published in Bureau of Mines Bulletin No. 18—"The Transmission of Heat into Steam Boilers." A careful study of this bulletin will reveal a number of interesting and valuable facts to the boiler designer. Some of the conclusions are so clear that they are worth quoting:

A boiler that has its heating plates arranged in such a way that the gas passages are long and of small cross-section is more efficient than a boiler in which the gas passages are short and of large cross-section.

If the same weights of gas at the same initial temperature are passed through a 2-in. and a 4-in tube, both tubes having the same length, the 2-in. tube will absorb more heat than the 4-in tube, although the 4-in. tube has twice as much heating surface as the 2-in. tube.

Locomotive boilers are as a rule more efficient than stationary fire-tube boilers, because the tubes in the former boilers have a smaller diameter in comparison with their length than the tubes in the latter boilers.

In multitubular boilers the true boiler efficiency increases as the diameter of the tubes decreases.

It is to be especially noted in connection with these quotations that the authors are referring to true boiler efficiency as contrasted with combined boiler and furnace efficiency.

Mr. Riggin does not tell us what limits he would impose. For my part, provided sufficient draft were available, if I were buying a boiler I should prefer the one with the small tubes within practical limits. For a return-tubular boiler 12 ft. to 16 ft. long I should prefer 3-in. tubes; 18-ft., 3- or 3½-in. tubes, and for 20-ft boilers, 4-in. tubes. For vertical fire-tube boilers up to 72 in. diameter by 10 ft. long, I should want 2-in. tubes; longer than 10 ft., 2½-in. tubes. If the tube-sheet layout has been made with due respect for circulation, water-storage space, etc., I would feel that I would be getting my money's worth in maximum heating surface as compared to the total weight of the boiler. Within these limits the objections to the smaller tubes would not be serious. R. B. DALE.

Troy, N. Y.

Repairs to a Centrifugal Pump

An 8-in. low-head, belt-driven centrifugal pump, used for irrigation purposes, was about to be condemned because it was old, the amount of water pumped was small, the end bearing ran hot, the stuffing box could not be packed to hold, and it was hard to prime.

Upon investigation it was found that most of the trouble was due to the end shaft bearing, which was of the ring-oiled type, having been babbitted out of line with the stuffing box with the result that the shaft, instead of centering in the stuffing box, was fully ⅛ in. out of center toward the belt side. Thus, instead of ¾-in. space for packing around the shaft there was a space of ¼ in. on one side and ½ in. on the other. This made packing difficult, and shredded-metal packing had been used with unsatisfactory results, as the bearing heated considerably and probably leaked air, thus making priming difficult.

End thrust of the shaft was taken care of by two collars, fastened to the shaft by setscrews, one at each end of the shaft bearing. Evidently, the rotor was badly out of balance, as the collar on the end of the shaft had worn the babbitt face on the bearing end and was cutting the iron beneath it. The bearing ran hot as a consequence, and some farm mechanic had drilled and tapped the bearing cap for two grease cups, which evidently failed to give the desired results, and so a water line was run from the pump discharge to the bearing and a stream of cold water was run on the bearing to keep the temperature down.

Upon disassembling the pump the rotor clearance was found to be approximately $\frac{3}{16}$ in. on both sides, and the bearing bushing on the inside end of the stuffing box was worn. With all of these faults it did not seem advisable to scrap the pump, and so it was decided to repair it. The rotor shoulders, which were 1½ in. wide, were turned down and two steel bands were made and shrunk on. Light cuts were taken to true the two corresponding faces of the shell, and the steel bands on the rotor shoulders were turned down so as to give a $\frac{1}{32}$-in. running clearance. A new babbitt bushing was made for the inside bearing, and the outside bearing was rebabbitted true with the stuffing box. The end play, which amounted to 1½ in., was adjusted by the aforementioned collars, by placing the rotor in the exact center of the shell and setting the collars so as to allow approximately $\frac{3}{16}$ in. end play. A good grade of metallic packing was used to pack the stuffing box. The grease cups were removed from the bearing cap and the oil ring put in use. As a result of these repairs the pump was primed in four minutes, whereas it had formerly taken from ten to fifteen minutes, a hand pump being used for priming. The bearing ran cool, and the capacity of the pump was increased exactly 50 per cent, at a cost not in excess of $75.

Norwalk, Cal. A. C. MCHUGH.

How Can the Air-Compressor Valves Be Prevented from Breaking?

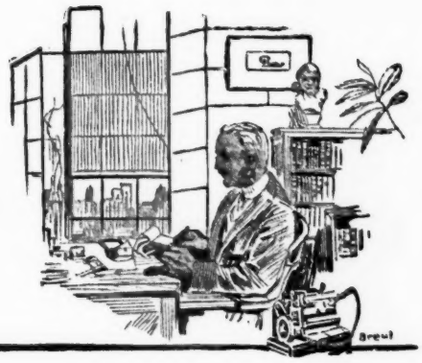
I am having trouble with the valves breaking on a motor-driven air compressor and would like to hear from some of the readers of *Power* who may have had experience along this line, as to what can be done to prevent this trouble.

The compressor is a 10 x 10-in., two-cylinder, vertical single-acting machine with splash oiling, operating at 225 r.p.m., belt-driven from a motor, and the discharge pressure is 75 lb. The valves are 3½ in. in diameter, $\frac{1}{16}$ in. thick with a 1-in. hole in the center. The seat supports them in the middle and around the edge by about $\frac{3}{16}$ in., and the center of the seat is connected to the circumference by six radii. A coil spring is placed on top of each valve to hold it on its seat. The valves furnished with the machine are of steel not hardened, but soon crystallize and notches break out of their outer edges. None of them has cracks as far as the center.

We have tried making them of ⅛-in. machine steel, and of ⅛-in. and $\frac{1}{16}$-in. tool steel, but so far nothing has stood the test. Annealing them is out of the question as it would mean, at least, a once-a-week job and the chances of warping the thin discs would be too great. Almost all of the breaking is on the discharge valve. Plenty of jacket water is circulated, and the air is discharged at a temperature of about 235 deg. F. Regulation is by the unloading method, the suction valve being held open by the unloader.

Wadsworth, Ohio. R. E. ECKARD.

INQUIRIES OF GENERAL INTEREST



Gas-Engine Efficiency—Does the efficiency of the gas engine depend upon the amount of heat in the gas mixture? R. L.

Disregarding mechanical losses, the richness or weakness of the gas mixture has no effect on the engine efficiency. This depends solely on the compression-pressure ratio.

Cross-Sectional Area of Pipe Material—What is the cross-sectional area of metal of a standard 2-in. iron pipe? J. B. S.

Nominal 2-in. iron pipe usually has an actual internal diameter of 2.067 in. and external diameter of 2.375, giving thickness of 0.154 in. Hence, the mean diameter of material is $(2.067 + 2.375) \div 2 = 2.221$, and the cross-sectional area would be $2.221 \times 3.1416 \times 0.154 = 1.074$ sq.in.

Use of Poppet Valves With Superheated Steam.—Why are poppet valves generally used in engines supplied with superheated steam? W. A.

Large valves and valves with rigid sliding surfaces, such as slide valves and Corliss valves, do not work well with highly superheated steam, as the large castings warp so the surfaces do not remain true and the absence of moisture in the steam to act as a seal leads to excessive leakage; and, in addition, lubrication of the valves becomes difficult with highly superheated steam.

Tank Capacity Reserved for Cooling Water.—How many pounds of water must be discharged from a tank filled to its capacity with 8,000 lb., of water at 180 deg. F. so the tank may be refilled with water at 60 deg. F. and obtain a temperature of 100 deg. F. for the mixture? S. F.

Each pound of cooling water at 60 deg. F., when raised to the temperature of 100 deg. F., would absorb 40 B.t.u.; and each pound of water cooled from 180 to 100 deg. F. would part with 80 B.t.u. Hence, the mixture would have to be in the proportion of 80 lb. of cooling water to 40 lb. of original tank water, and to make room for the cooling water, it would be necessary to discharge $\frac{80}{80 + 40}$ of 8,000 $= 5{,}333\frac{1}{3}$ lb. of the original tank water.

Woolf Type of Compound Engine—What is the Woolf form of compound steam engine? M. E.

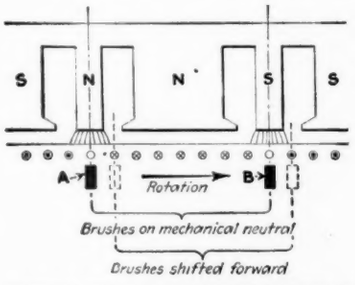
The earliest form of compound steam engine, patented in England by Arthur Woolf, consisted of a high-pressure cylinder alongside of a low-pressure cylinder, each having its piston operating on the same end of a beam. Each end of the high-pressure cylinder discharged to the opposite end of the low-pressure cylinder through the shortest convenient connecting passage without a special receiver between the cylinders. The same relative arrangement of cylinders, discharge of steam and operation of pistons is obtained in the "duplex" compound and the same direct discharge of steam from the high- to the low-pressure cylinders without a receiver, is obtainable in the tandem-compound and also when the high-pressure and low-pressure pistons operate on cranks set at 180 deg. apart. Otherwise there cannot be continuous flow of steam from one cylinder to the other and the high-pressure cylinder exhausts into a special reservoir or receiver. Hence, compound engines are commonly recognized as reducible to two forms—one in which the steam from the high-pressure cylinder is exhausted direct into the low-pressure cylinder as in the Woolf engine; and the other form in which the steam from the high-pressure cylinder is exhausted into an intermediate reservoir, whence the steam is supplied to and expanded in the low-pressure cylinder, as in the "receiver-engine"

Steam Required for Heating Water.—What quantity of steam at 100 lb. gage would be condensed when discharged into 400 gal. of water contained in an open tank, to raise the temperature of the water from 40 deg. to boiling? H. M.

The initial 400 gal. of water would weigh $400 \times 8\frac{1}{3} = 3{,}333$ lb. and neglecting losses of heat from radiation, to raise the temperature from 40 deg. F. to the temperature of boiling at atmospheric pressure would require $3{,}333 \times (212 - 40) = 573.276$ B.t.u. Assuming that dry saturated steam is supplied at the pressure of 100 lb. gage or 115 lb. per sq.in. abs., then each pound (weight) of the steam would contain 1,188.8 B.t.u. above 32 deg. F. and, in becoming condensed to 212 deg. F. would part with $1{,}188.8 + 32 - 212 = 1{,}008.8$ B.t.u.; and since heating the water would absorb 573,276 B.t.u., the amount of steam condensed would be $573{,}276 \div 1{,}008.8 = 568.3$ lb.

Brush-Shifting in Interpole Generators.—Why does shifting the brushes forward on an interpole machine cause the voltage to drop more rapidly as the load increases? J. H. B.

Referring to the figure, when the brushes are set on the mechanical neutral, the interpole flux divides approximately equally on both sides of the coil under commutation. Therefore the total flux entering the armature and effective in generating voltage between brushes *A* and *B* is composed of the flux from the main north pole plus approximately half the flux from a north interpole and half that from a south interpole. The interpoles therefore generate voltages approximately equal and opposed to each other that neutralize each other, and the net generated voltage is that produced by the main pole flux alone. If the brushes are now shifted in the direction of rotation, the amount of north-interpole flux added to the main north pole between brushes *A* and *B* is decreased, and the amount of south-interpole flux is increased, with the result that some of the latter generates voltage opposed to that of the main north pole and lowers the voltage as the load increases.



BRUSH-SHIFTING IN INTERPOLE GENERATOR

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Boiler and Furnace Design*

By Dr. D. S. JACOBUS†

TO APPROACH perfection from a thermal viewpoint, a boiler and superheater, including its economizer and air heater, if used, should absorb a maximum amount of heat with a minimum draft drop. There are commercial elements entering into the problem that limit the application of this principle, and so many variables that each case must be considered by itself in order to arrive at the best arrangement. A relatively large amount of boiler-heating surface, with large flow spaces for the gases, if properly insulated to prevent undue radiation, would more nearly meet the requirements of absorbing a maximum amount of heat from a given weight of fuel burned with a minimum draft drop than a smaller amount of surface, although the latter would in most cases be preferable from a commercial point of view. Adding an economizer will ordinarily add to the thermal efficiency; the same applies to an air heater, but here again, on considering the commercial side, it may be found that the character of the load and the class of operation and fuel conditions are such that it will not pay to install an economizer or an air heater.

Determining Whether an Economizer Will Pay

In determining whether it will pay to use economizers in a new plant, the problem should not be approached by comparing the efficiency of a boiler with that of the same boiler with an economizer added to it. The proper way is to compare the results to be expected from boilers best suited for the service without the addition of economizers to those to be expected for the best combination of boilers and economizers.

It will sometimes be found for exceptional load conditions that a larger boiler properly designed and baffled will give better commercial returns, all features considered, than a smaller boiler with an economizer—or, for that matter, for any boiler that can be selected with an economizer. In the case of an old plant the question of whether it will pay to add economizers to the boiler is a more simple one to answer than for a new plant, as the added efficiency due to the economizers may be readily computed on the basis of the known flue-gas temperatures, gas weights, etc.; but here again the load conditions must be taken into account, as well as the fact that there will be an increased cost of upkeep and added complication through the necessity of installing an induced-draft apparatus.

For peak load service it does not usually pay to install economizers on all boilers. A good arrangement may be secured for some classes of service by adding economizers to, say, one-third of the boilers, operating them at a more nearly uniform load than the rest and cutting in those that have no economizers during the peak-load periods.

Another case where it does not pay to apply economizers is where boilers are used for stand-by service. The cost of fuel is a governing factor, and because of the increase in fuel costs during the last few years we are approaching more closely to European practice in the number of boilers so fitted.

In designing a boiler for use without an economizer, additional efficiency may be secured by adding to its height. Increasing it from, say, 14 to 20 tubes high will result in a considerable increase in efficiency without a corresponding increase in the draft loss, as much of the draft loss in boilers comes through the turns made by the gases in passing over the baffles.

Wrought-steel economizers are coming into use to a greater extent than formerly. We have found that, if the oxygen content of the feed water is reduced so that it does not exceed ½ c.c. per liter, the corrosion is reduced to a point where it will not give trouble.

To avoid exterior corrosion through the condensation of moisture from the flue gases, the temperature of the feed water to the economizers must be kept above a temperature of about 120 deg. F., and for most work we recommend 140 deg. F., as this allows for some leeway in case the water is fed intermittently. There is more difficulty through exterior corrosion in intermittent service than where the service is more or less continuous, as soot that collects on the outside of the economizer is likely to become moist while the economizers are down or are being started up, and the presence of moisture makes the soot from certain fuels highly corrosive.

It is becoming more general practice to use an individual economizer on each boiler and not to install connections for bypassing the gases around the economizer. A bypass connection as a rule allows some leakage of the hot gases and causes a continual loss of efficiency, and its omission is also advantageous in simplifying operation and lessening the chance of trouble with the economizers.

Brickwork in Furnace Design

For securing the highest efficiency the furnace temperature should be the maximum that can be maintained, and combustion should be completed within the furnace chamber. The furnace brickwork employed today will fail if saturated with heat at the full temperature that is available with many classes of fuel. In furnace design, therefore, some efficiency must be sacrificed in most cases in order to maintain the furnace brickwork and keep the cost of repairs within a reasonable figure. If it were possible to secure refractories for furnace construction that could be brought up to the full available temperature, the art of furnace design would be considerably changed, but as it stands today most of the thickness of the brickwork must be cooled to a temperature below, say, 2,200 deg. F. in order that the bricks or tiles will carry the load imposed on them. To accomplish this a sufficient amount of the heat absorbed by the brickwork must be dissipated either through radiation or convection.

Where furnaces are operated under a suction that causes the cool air to be drawn inward through the brickwork, there is a cooling effect that serves to prevent overheating, whereas if they are operated under a pressure, there is a tendency for the hot gases to leak outward and overheat the brickwork. The difference between running with a slight suction of, say, 0.10-in. water column and a plus pressure within the furnace may make all the difference between successful operation and having a lot of trouble. If it were possible to operate with a plus pressure and maintain the brickwork irrespective of the temperature to which it would be raised, more economical results could be secured in most cases through the elevation of the furnace temperature. The exception would be where the elevation of temperature would interfere with the combustion; for example, with some kinds of coal too high a temperature might fuse the ash and clinker and cause the coal to mat down on the grate so as to greatly increase the air resistance through the fuel bed and reduce the available capacity. Again, if it were possible to bring the brickwork up to the full furnace temperature, arches could be used for certain purposes in furnace design where they can not at present.

Brickwork will fail by plastic deformation before it reaches the melting point. The greater the load carried by the brick the more likely it is to fail. Fireclay brick of the best quality ordinarily obtainable begins to show plastic deformation under a load of 20 lb. per sq.in. at from 2,200 to 2,400 deg. F. Reduction to a load of 10 lb. per sq.in. will increase the permissible temperatures about 200 deg. F. As furnace temperatures considerably higher than this

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*Abstract of a paper delivered before the Cleveland Engineering Society and local section American Society of Mechanical Engineers at Cleveland, and the Akron Section at Akron, Ohio, April 26 and 27, 1921.

†Advisory Engineer, the Babcock & Wilcox Company.

exist with certain grades of fuel and stoker practice, say, 2,700 to 3,000 deg. F. as a limit, it is apparent that the necessity of maintaining the brickwork below the temperature of the furnace is a vital one. First-class clay brick have a fusion point slightly above 3,100 deg. F., and yield through plastic deformation long before they fuse.

In ordinary furnace design the walls and arches are heated on one side only in order that the brickwork may be maintained at a lower temperature than that of the furnace. Arches will give trouble if heated on both sides which would not if subjected to the same amount of heat on one side only. This sometimes makes necessary the use of double arches, one directly above the other, with a small amount of air admitted between them for ventilating and cooling. A wall of a given thickness that would give good service as a battery wall might fail under the same fuel and combustion conditions if used as a supporting wall between two combustion arches, as the heat would not be conducted away from the wall to the extent that it would when used as a battery wall, and the reflected heat from the arches would also increase its temperature. Such a supporting wall should be used between combustion arches only in cases where a low grade of fuel is burned which does not result in high temperatures, or it should be ventilated.

To consume the combustible gases within the furnace chamber there should be a proper length of flame travel before the gases strike the tubes and a sufficient furnace volume. Furnace volume and length of flame travel are not, however, the only elements that must be considered in designing an efficient furnace, as there must be a mingling action within the furnace to cause any unconsumed combustible gases to reach the excess air.

Effect of Radiant Heat

The effect of the absorption of radiant heat on the boiler tubes should be considered in designing a furnace. With certain fuels such as blast-furnace gas, wet wood or bagasse, where the highest attainable temperature can be carried by the brickwork, it is best to absorb but little radiant heat in order to maintain a high furnace temperature and thereby increase the efficiency of combustion. With the stronger fuels it is necessary to absorb a considerable amount of the radiant heat in order to prevent the collapse of the brickwork or an undue amount of deterioration.

Few realize how great a proportion of the heat may be absorbed by a boiler as radiant heat. In underfeed-stoker practice, with the baffle arrangement ordinarily offered with Babcock & Wilcox boilers, the absorption of radiant heat with the boiler operated at its normal rated capacity is over 60 per cent of the total heat absorption. Exposing more or less of the boiler surface to the direct radiant heat of the fire has a comparatively small influence on the efficiency, as any increase in the heat absorbed through direct radiation is counterbalanced to an extent by the diminution of the amount of heat absorbed through conduction. Ordinarily, the higher the furnace temperature the higher the efficiency. Higher furnace temperatures, however, lead to increased cost of brickwork maintenance, especially when the boilers are operated at high ratings, and for a strong fuel it usually pays to expose a considerable proportion of the heating surface of the boiler to the direct action of the radiant heat.

Percentage of Rating for Economical Operation

A question often arises as to what is the most economical capacity or rating at which a boiler should be run. This cannot be answered in a general way, as it depends on the load conditions as well as on the class and cost of the fuel. The economical rating is naturally influenced by the presence or absence of economizers and the service to which the boilers are put. Where there are short peak-load periods, the greatest commercial economy is usually secured by operating the boilers to as high a capacity as can be secured during these periods. Each case must be considered by itself and the fuel economy worked out for the actual conditions of service. The effect of the additional cost of upkeep must naturally be considered.

The general practice in this country is to drive boilers at a higher rating than is done in European practice, and the stress of war conditions has undoubtedly led to a number of plants being run beyond the point of the best commercial efficiency. The fact remains, however, that boilers are being run at higher and higher capacities in our modern power plants, and the tendency seems to be upward rather than downward.

A furnace for operating at high capacities should be larger than for operating at lower capacities; a furnace to give economical results at high ratings therefore involves special problems in caring for the expansion of the brickwork and especial care in the construction of buckstays for holding the brickwork in alignment. The general tendency in large furnace walls which are highly heated, is to bulge inward toward the fire, and unless some means are provided to prevent this, they may collapse.

In our present practice we use bonding tile which are held by cast-iron bulb pieces attached to the buckstays in such a way that the wall can expand in any direction in a generally vertical plane, whereas it is prevented from either bulging inward or outward. Another means that may be employed to prevent the walls bulging inward toward the fire is to build them with a camber having a vertical axis, that is, curved slightly, with the concave side next the furnace.

Difficulties Encountered From Slag

In operating at higher ratings, difficulties are encountered with some grades of fuel through slag adhering to the boiler tubes and restricting or closing up the passageways for the flow of the gases. The difficulty through slag can be reduced by providing a relatively large area for the flow of the gases on entering the spaces between the tubes and by furnishing access doors through which the slag can be detached from the tubes. An air lance, which is used both for cooling the slag and as a rod for striking it to remove any portion that may adhere to the tubes, forms an efficient tool for use in connection with the access doors.

The difficulty through slag is essentially a stoker-operating difficulty. Carrying a thick fire may result in but little slagging action, whereas this may cause trouble with the stoker itself through clinker. Thinner fires may remedy the clinker difficulties but result in a greater amount of slag being deposited on the boiler tubes. With certain grades of coal there will be some accumulation of slag on the boiler tubes with the stokers most carefully operated, and it is advantageous in such cases to provide access doors for removing the slag. Steam-jet blowers serve to reduce the amount of slag which will collect on the tubes, but are not a complete remedy so that it is often well to provide access doors.

How To Reduce Clinker Trouble

Trouble from clinker at the sides and front walls of the furnace where underfeed stokers are used is often reduced by admitting air through a number of openings in the walls at the sides of the fuel bed. The air flows in a layer against the inner face of the wall and prevents the clinker adhering to them. It also serves to partly cool the wall and reduce its erosion.

A stoker-operating difficulty that arises in some cases is the formation of a clinker which will cause the air admitted under a blast pressure to produce a jet or torch-like action that will result in fusing the brick so as to melt out or erode away a part of the wall. The stoker tuyeres may also cause jets of air to be projected against the wall so as to erode away certain parts of it.

It can readily be seen that furnace design and boiler design must be co-ordinated in order to secure the best results. It is impossible to separate boiler efficiency from the efficiency of the stoker and furnace. Many have worked on this problem, and the ground has probably been gone over more thoroughly than any other feature of boiler-testing codes. The result has always been in reaching the conclusion that it is impossible to separate the furnace and stoker efficiency from the combined efficiency of the boiler, stoker and furnace in such a way that the result may not be misleading.

Boiler Explosion at Monterey, Tenn.

AN EXPLOSION occurred in a planing mill at Monterey, Tenn., March 31, when a 48-in. by 16-ft. return-tubular boiler failed, partly wrecking the mill and injuring a dozen men, one probably fatally.

The employees of the mill were not skilled men, and it was difficult to get any statements that would lead to a satisfactory conclusion regarding the explosion. However, the immediate cause was the weakened condition of the shell, due to excessive corrosion.

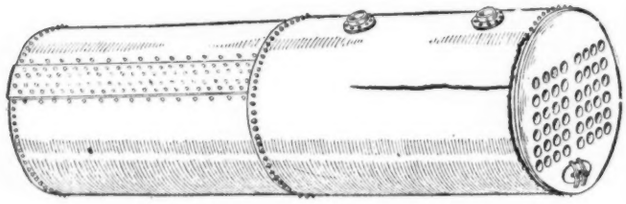

FIG. 1. INITIAL FAILURE OCCURRED AT WATER LINE ON FRONT SHEET

The boiler had been in service for more than twenty years, and there is no evidence that it had ever been inspected during that time. It was first used in a backwoods sawmill and was removed to its last location about fifteen years ago, where it had been used off and on ever since. The water at this location is very corrosive, and the metal at the water line had been reduced to about $\frac{1}{16}$ in. or less, so that the boiler must have been on the verge of failure for some time.

On the day of the explosion the boiler had been fired heavily during the forenoon, as the equipment was badly overloaded. After the noon hour, the attendant, who acted as fireman and engineer, having noted, so he says, two gages of water and 100 lb. pressure, stepped into the engine room and cracked the throttle. Immediately, he states, he heard a hissing sound and felt what he thought was a gust of air. He ducked behind the engine, and this saved his life, as the piping, governor and throttle were swept away by a bombardment of grate bars and brick.

FIG. 2. FLATTENED SHEET OF THE RUPTURED COURSE THROWN A DISTANCE OF 100 FEET

The machine operators in the mill proper were standing in a group within the mill, not having gone to their respective machines. All of these men were more or less injured, one operator being found after the accident, covered with fragments of hot brick and a full barrel of roofing paint, which was blown from its place by the side of the boiler setting, sixty feet into the mill. This man will probably die from his injuries.

The water column and steam gage were destroyed, and the safety valve was so broken that it was impossible to tell whether any of the attachments were in working order. Several workmen agreed that the boiler "popped" at 105 lb. gage, and that it had "popped" shortly before the accident. As the gage had never been tested, it is impossible to reduce the "105-lb. gage" to pounds per square inch in ordinary parlance.

Indications are that the rupture started at the intersection of the longitudinal and circumstantial rents, Fig. 1, and extended halfway around the head, the metal being torn loose principally on the center line of the rivet holes, as shown. It extended toward the rear end along the water line also, the metal all along this portion of the shell being very thin. The section was flattened out and thrown about 100 ft. from the setting, as shown in Fig. 2. The other end of the boiler was torn loose on a line following the girth seam and was blown against a dry kiln 200 ft. distant. This section entered the dry kiln and moved the entire structure, together with its contents, about a foot from its foundation.

Fig. 3 shows the condition of the plate at the point where the initial rupture occurred. The metal curled back at the lower part was so thin that it could be broken off with but little difficulty. This condition obtained along this line, over the greater part of the shell, although the thickness of both shell and heads was good at all other points. The boiler was comparatively free of mud and scale and, with the exceptions noted, was probably good for 80-lb. pressure.

FIG. 3. SHOWING THINNED CONDITION OF TORN PLATE ALONG THE WATER LINE

The owners of the plant were genuinely distressed at the accident, aside from the monetary loss, as neither of them was experienced with machinery and boilers, and it had not occurred to them that their boiler might explode some day. They were interested to know that they could have had their boiler insured for a nominal sum and could have availed themselves of the services of an expert inspector during the period of insurance. This would have resulted, of course, in immediate condemnation of the boiler. It was rumored that the boiler had been condemned several years ago, but of this no evidence could be found.

Throughout this section of Tennessee, which was formerly a great hardwood lumber region, there are steam boilers of various sizes that have been idle for several years, as the supply of timber is exhausted. From time to time a mill owner goes out into the hills and picks up a boiler which he thinks would be "about right" to furnish steam for his plant. These boilers, exposed for a long time to the weather, many of them badly corroded, sell for a song, and it is a constant temptation to bring them back into service. They represent, however, so many potential disasters, and in the absence of state boiler laws to prevent their use, it is only a matter of time until we hear that another one has exploded and human life has paid the penalty of ignorance and neglect.

Increasing the Efficiency of Water-Power Plants*

By CHARLES M. ALLEN, M.S.
Professor of Hydraulic Engineering, Worcester Polytechnic Institute

A BRAKE test in the field has several advantages over an electrical test. With the brake test the wheel can be operated at various speeds at different gate openings and in this way complete characteristics of the wheel determined. This is not possible with the electrical test because the speed of the wheel must be the same for all gate openings unless the generator is given an individual rheostat load, and even then any wide variation from the normal speed throws in some doubt as to the efficiency of the generator under these new speed conditions. The

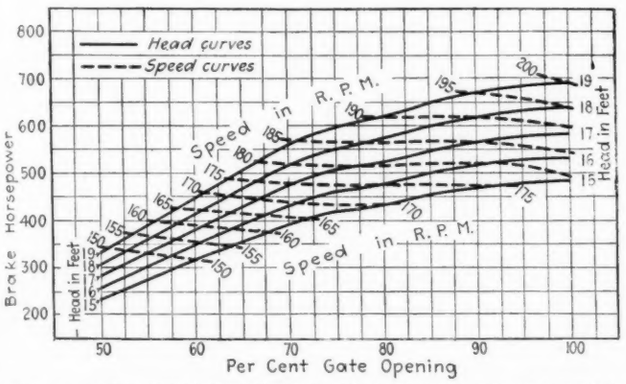

FIG. 1. SPEED-HORSEPOWER CURVES FOR HEADS FROM 15 TO 19 FEET

dynamometer can be easily calibrated on the ground where all parties interested can check up all measurements and be absolutely sure the true output of the wheels is determined.

The water measurements of wheel discharge under test very often introduce a good many difficulties. The particular setting of the wheels is a determining factor as to what method of measurement shall be used. However, in most cases some one of the standard methods can be used which will give results sufficiently accurate for all commercial requirements.

Water-Power Plants Get Little Attention

It is a curious fact but one well worth contemplating, that in a large number of manufacturing plants using both steam and water power, the steam plant usually receives most excellent attention, while the water-power plant gets little if any. Water power users in such plants do not fully realize that a horsepower developed by the waterwheel is just as powerful and just as valuable (though apparently not as respectable) as one developed by the steam engine or turbine. Some people seem to think water power costs nothing after the wheels are installed, perhaps because they do not get a water bill every month, while with a steam plant the monthly coal bill makes a different impression. The foregoing applies to isolated plants that own their water rights—for example, a paper mill on a perfectly good water privilege capable of furnishing the entire power demand of the mill but actually making up from 1,000 to 2,000 kw. by steam simply from lack of attention in operating and properly equipping the hydraulic plant.

The recent and probably future high cost of coal and its transportation is at least one perfectly good reason why it is going to pay from now on to look after power-plant efficiency. On account of this increased cost of fuel a large number of small water powers can be developed and successfully financed today that had to be passed by only a few years ago.

*Abstract of paper presented before the Technical Association of the Pulp and Paper Industry at the Sixth Annual Meeting, New York, April, 1921.

The purpose of this paper, however, is to point out how existing plants may be operated more efficiently. In a large number of cases the first thing to do is to determine the present operating efficiency. This point has been sadly neglected in the past. In hydro-electric stations it is just as important to know the "water input" as the "watt output" if a plant is to be successfully operated. In these stations the switchboard is usually covered with all kinds of instruments, both indicating and recording, but having to do only with the electrical output. Very seldom will any apparatus be found that either records or indicates the water input.

Power and Efficiency Tests

In groundwood mills, it is just as important to know how much water is used under a given head as to know the groundwood output of the plant if the highest operating efficiency is to be attained. As an example of what is sometimes found, a mill in which are six units of 2,000-hp. capacity was operated over a year where the rule was never to run a grinder unit unless it was run at full gate. Power and efficiency tests were made and it was found that very little if any more power was developed by the wheels above 0.85 gate, but that the discharge continued to increase up to full gate. After the tests were made, the wheels were never opened above 0.85 gate and practically enough water was saved by running five units at 0.85 gate to operate the sixth unit. The saving was immediately noticed in the mill, and whereas this mill had been buying pulp from Canada, it now furnishes all it needs.

Experience in testing wheels in place has shown that although there are some waterwheels that have been operating even thirty to forty years and are still doing good work, yet a much larger number should be sent to the scrap heap and replaced with modern high-efficiency wheels.

One of the principal causes of low operating efficiency is due to improper settings. It is impossible to make a poor wheel an efficient one by placing it in a good set-

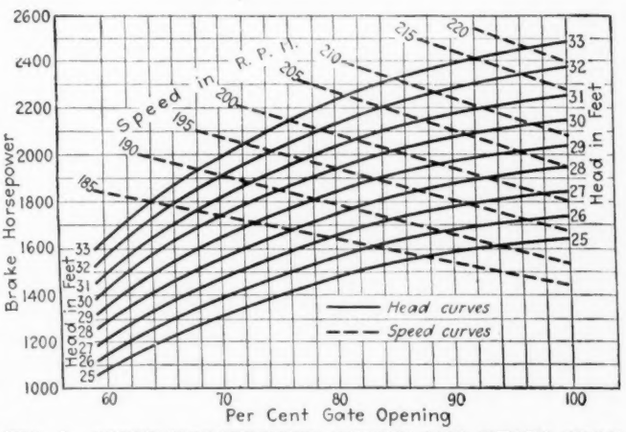

FIG. 2. SPEED-HORSEPOWER CURVES FOR HEADS FROM 25 TO 33 FEET

ting, but an efficient wheel can be tremendously crippled by placing it in a poor setting. By setting is meant the intake, casing or flume, draft tube, and tailrace.

In many cases the mill or factory has grown from small demands of power to larger, and in order to meet these demands larger wheels have been installed in the original settings. With the exception of a few rare cases this is bad practice so far as the efficiency in the use of water is concerned; and in a good many cases very little if any power was obtained. As an example of this type of practice, a plant was operated by wheels that had increased the

capacity of the plant from a unit of 700 to a unit of 2,800. New wheels had been installed in the old flumes to get this increased capacity, but at the cost of a very marked decrease in efficiency. Not only that, but the main shafting had been kept the same and was replaced only when it broke. The policy of the concern was to repair damages after the breakdown and charge it up to an act of Providence.

A considerable increase in power and efficiency can be obtained at little or no expense by simply taking as good care of the water-power installations as is ordinarily given to steam-power plants. Waterwheels should be inspected every month or two to make sure the shafts are lined up, that the runners have the proper clearance, are free from débris, etc. There are too many operators as well as men higher up that never give waterwheels much thought until something happens. In some plants it takes the oldest living employee to tell not only when the wheels were last inspected, but sometimes where they are located. A breakdown can often be avoided and a much higher operating efficiency secured by a continuous systematic inspection.

Care of Trash Racks

Trash racks should be kept free; a considerable loss in head occurs at this point from neglect. This loss in head becomes a greater loss in power, because if the wheels were properly chosen for the normal head, any reduction causes the wheel to operate at the wrong speed for best efficiency, especially at the part-gate loads. The loss of head at the racks in low-head plants may become a serious one. For example, a plant consisting of ten or eleven units of approximately 2,000 hp. each having racks 29 ft. long and having accumulated bark, etc., to a depth of 16 to 17 ft. from the bottom, used only the upper 12 to 13 ft. of rack, primarily because the man whose business it was to keep the racks clear had rake handles only that long.

If old-style vertical wheels stand idle during low-water periods, the buckets very often become covered with tubercles which, unless removed, decrease their efficiency, sometimes from 10 to 15 per cent and the power from 20 to 30 per cent, depending somewhat on the size of the wheel.

Obstructions in the draft tube and tailrace, causing water to back up, thus reducing the head, are all too common. One of the worst cases of this sort occurred at a new hydro-electric plant where the wheels had been operating about a year, and comparatively little power was obtained. A test was called for, and the actual horsepower of the unit showed about 100 instead of 800, the guaranteed output. Investigations were made, and it was discovered that the boilermakers had built a staging platform directly under the end of the vertical draft tube, and this platform for some unaccountable reason was left in. The only possible chance the water had of getting through that unit was between the cracks in the planks. While this sort of thing is unusual, it only goes to show how some things get by.

Running with Head Gates Partly Closed

Not opening head gates wide enough owing to a poor rig or laziness on the part of the operators is a frequent cause of reduced head and is really inexcusable. A good many old plants have been operated during their life with head gates partly closed, one plant in particular having been operated twelve years with the gates opened only 8 ft. instead of 18 ft., thus losing nearly 2 ft. head between forebay and open flume, the reason for this being that bolts in the gate stems hit a channel iron which ran along the entire front of the power station.

If headgates are used frequently (and they should be in most plants) power-operated gates of some sort should be installed. They pay for themselves in a short time, not only in the saving of labor, but in the increased efficiency of the plant because of more frequent inspections. If wheels are shut down any considerable length of time on account of low water, the headgates should be closed and cindered to prevent all possible leaks. The wheel gates are not usually tight enough for this purpose.

Tests have shown that wheels are often operated at the wrong speeds for maximum power and efficiency. The accompanying charts give curves showing the proper speeds to operate wheels to give maximum horsepower for different heads and gate openings. These charts combined with the use of a tachometer on the wheel shaft and net head gages give all the power data necessary to secure maximum output.

Much could be said concerning the use of available flow in plants having several units. In general, the load should be so proportioned as to get the most power out of the water used. The daily operating head should be kept as high as possible, except for special reasons, such as peak loads or emergency causes. Many plants are continuously run under reduced head from simple lack of attention or plain ignorance on the part of the operator. A good many operators pull the pond or forebay level down the first thing in the morning and then run under these low-head conditions the rest of the day, and when asked for the reasons, apparently have no real ones.

It may seem that the examples used to illustrate the various shortcomings in water-power plants are exaggerated, but they are all taken from actual conditions.

It should also be stated that a large number of waterwheels have been tested and found to be up to and above their guarantee. This is especially true of the more modern large units. Within the last few years several large vertical hydro-electric units under test have shown an over-all efficiency of 90 per cent.

In order to operate existing plants up to their maximum efficiency, more regular attention should be paid to the actual operating conditions of each essential part of the hydraulic layout. Eternal vigilance coupled with common hydraulic horse sense will in a large measure accomplish this purpose.

The Drying of Pulverized Coal*

One of the biggest and most expensive pieces of machinery in the preparation plant is the drier. In the past it has been considered necessary to dry the coal down to 1 or 2 per cent of moisture in order properly to pulverize, feed and burn the coal. The latest practice indicates that it is not necessary to have the coal anywhere near this low percentage of moisture, and in some cases it is possible to operate without using the driers and to design and install the plant without them. The Allegheny Steel Co. has operated for three years without driers, and the new Ford Motor Co. installation has been built without them. There is no doubt, also, that progress will be made in perfecting the driers where they are used, so as to reduce the cost of installation and operation. There is, in addition, a strong possibility of development so as to dry the coal either in steam driers or by the utilization of waste gases where drying is deemed necessary.

The net over-all efficiency is about the same whether the moisture is taken out of the coal by pre-drying or evaporated from the coal in the boiler furnace. There is, if anything, a slight advantage in favor of the latter.

According to *The Engineer* a fire-resisting plastic material consisting of equal weights of paper paste and a mixture of equal parts of calcium carbonate and magnesium silicate makes a product that may serve as a practically incombustible substitute for various compositions. It may be used for making stereotype molds, as a finish for walls and for many other purposes. It is made waterproof by varnishing or painting.

It will surprise many to learn that electric power is being exported—not across the ocean, of course, but by Switzerland to her neighbors. The authorized exportation of electric power from that country on Dec. 31, 1919, in kilowatts was as follows: To Italy, 44,510; to France, 32,207; to Germany, 29,710; to Austria, 2,500. This condition is a natural one, in view of Switzerland's tremendous water-power resources.

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*From a paper by Loren L. Hebberd, presented before the Technical Association of the Pulp and Paper Industry.

Washington News

Coal Commissioner Bill Remodeled—Mine-Mouth Plants in East Declared Impracticable—Lake Coal To Be Cheaper

By Paul Wooton
Washington Correspondent

After extended discussion before the full membership of the Interstate Commerce Committee of the Senate, Senator Frelinghuysen has rewritten his coal commissioner bill, which now becomes a bill "To aid in stabilizing the coal industry."

The revised bill vests practically all the provisions of the coal commissioner bill in the Secretary of the Interior. The appropriation is increased from $50,000 to $200,000. The provisions of the bill are to apply, in addition to anthracite and bituminous coal, to "semi-anthracite, sub-bituminous, lignite and coke."

It is the intention of Senator Frelinghuysen to hear a few specialists, but general hearings on the measure are not to be reopened. J. D. A. Morrow has been invited to present his views, and James Barbour, a traffic specialist from Canton, Ohio, who is in the service of a large consuming manufacturing industry, also is to be heard.

The seasonal freight rate bill also will be revised, it is believed. It now seems probable that the bill will be drawn so that the matter of granting seasonal rates will be left entirely to the Interstate Commerce Commission.

Mine-Mouth Plants Not Feasible

The study of the superpower plan for the Boston-Washington area has proceeded sufficiently far to determine that it is impracticable to locate large power plants either at the mine mouth or elsewhere in the coal-mining regions of this district.[1] It has been found that there is insufficient water available for condensing purposes. It is estimated that 800 tons of condensing water are required for each ton of coal put under boilers, and there are no streams that could be relied upon in the mining districts to furnish any such quantities of water as would be required by plants of the size contemplated. Even the large nearby-by rivers seem to have been eliminated from the consideration. The eastern branch of the Susquehanna River is said to carry too much sulphur to allow of its successful use in connection with a large power plant. The Delaware River would be eliminated, it is believed, because the storing and discharging of water in connection with the operation of a large plant would make for an irregular flow of the river, which would interfere with its use for power purposes.

It also has been demonstrated that the steam sizes of anthracite are too valuable to be considered as fuel at a superpower station. No one mine would be able to provide sufficient culm or waste coal for the operation of such a plant. Another conclusion which, in itself, is regarded as sufficient to defeat the mouth-of-mine plant plan is the comparatively short life of any one mine, when called upon to supply the needs of such a large plant.

Lake Coal Prices Down

A decrease of 28 cents per ton on the coal shipped to lower Lake ports for transshipment by water has been authorized by the Interstate Commerce Commission. An adjustment of the rates between the upper Lake ports and rail destinations in the Northwest is still under discussion, as this is written.

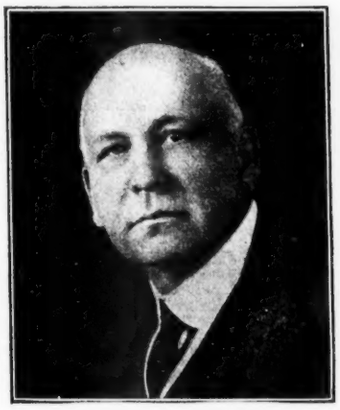
This order is expected to stimulate the movement of coal to the Lakes from Ohio, West Virginia and western Pennsylvania. It will have an adverse effect, however, on the movement of Illinois and Indiana coal into the Northwest and protests from that section are expected.

The City of Los Angeles has filed an application with the Federal Power Commission asking for a preliminary permit to cover two power installations in San Francisquito Canyon. The power installations are to be operated in connection with the Los Angeles-Owens River aqueduct. The power is to be used for public utility purposes. The estimated average horsepower that is to be generated is 30,000. The maximum capacity is 70,000 horsepower.

[1] The Colfax station of the Duquesne Light Co., however, (described in *Power* for April 5, 1921) is a notable exception, as it is a large mine-mouth superpower plant.

Charles L. Newcomb Has an Anniversary

The fortieth anniversary of the day on which Charles L. Newcomb became superintendent of the Deane Steam Pump Co. at Holyoke, Mass., was the occasion of a celebration arranged by the employees at the plant on April 21. As a permanent token of their regard the employees presented Mr. Newcomb, now manager of the company, with a silver testimonial. Harry M. Chase, an engineer who has been with the company since 1891, made the formal presentation and expressed the hope that he would see a golden jubilee ten years hence.



CHARLES L. NEWCOMB

The principal speaker was James J. Murray, a member of the Deane organization for twenty-one years, who praised Mr. Newcomb highly for his energy in building up the big Deane works of today, now a part of the Worthington Pump and Machinery Corporation, from the little plant that was its predecessor back in 1881.

Mr. Newcomb was called upon for a few remarks and responded with his thanks and appreciation of the friendship and loyalty of those with whom he had worked. He was especially gratified that so many of his employees had served with the company for such long periods of time.

THE EMPLOYEES' GIFT

Mr. Newcomb is active in engineering society affairs and has been prominently identified with the National Founders Association and the National Metal Trades Association. He served as president of the New England Foundrymen's Association and in other capacities in various employers' associations. He has been a member of the American Society of Mechanical Engineers since 1883 and is now a manager of the society. In 1919 he took active part in the organization of the Engineering Society of Western Massachusetts, of which he was the first president. Both of these societies were represented at the celebration, and numerous floral tributes and congratulatory messages were received.

Only 50,000 hp. of the available water-power supply of New Zealand is at present being used. The minister of public works has stated that electricity from water power could economically take the place of 1,250,000 tons of coal annually, which is about half of New Zealand's present needs.

State Water-Power Development Urged in California

A hydro-electric power commission along the same general lines as the Hydro-Electric Power Commission of Ontario is proposed in a bill now before the committee on government efficiency of the State Senate of California. It would consist of three commissioners, two appointed by the governor and a third, the chairman, elected by the municipalities involved.

The commission is empowered to buy or lease land, water power, machinery and everything necessary for the generation and transmission of electricity, to exercise the right of eminent domain and to construct new power plants. In the name of the State of California it could obtain licenses from the United States and make agreements involving interstate waters with the Federal Government or with separate states.

Under the act contracts could be made with municipalities for the supply of electricity, and rural syndicates could be formed, which could also make such contracts. The commission is authorized to purchase electricity for distribution and resale.

It is said that the bill has a chance of passage, and it is being watched with interest on the Pacific Coast.

Trieste, the greatest harbor of the Adriatic, has in its close vicinity large water resources that have not yet been utilized for power supply or for the improvement of the inadequate and inefficient water supply of the city. A Milan electricity company, however, has submitted to the municipality plans for a hydro-electric power station in connection with a water-works. The plans provide a catchment basin in the river Reka of 21,000 acre-ft. capacity. From this basin the water will be conducted through a canal, partly open, partly running as a tunnel, through the Karst Mountains to two power stations, one at Borst, the other on the outskirts of Trieste. An output of 30,000 hp. is expected.

New Publications

ENGINEERING OF POWER PLANTS. By Fernald and Orrok. Second edition. Published by McGraw-Hill Book Co., Inc., New York City. Cloth; 6 x 9 in.; 577 pages; 320 illustrations. Price $5.

This second edition of "Engineering of Power Plants" contains all the valuable engineering information embodied in the first edition, together with considerable new material. The value of this book lies in the abundance of practical data given, making it suitable both as a textbook and as an engineer's reference book. It is notable as giving serious attention to the subject of gas producers, although it is unfortunate that like attention has not been given to other forms of internal-combustion engines.

PAMPHLETS AND CLIPPINGS IN A BUSINESS LIBRARY. By Virginia Fairfax. Published by the *Journal of Electricity and Western Industry*, San Francisco, Cal., 1921. Paper; 4½ x 7 in.; 62 pages; illustrated.

The ever-present need for reliable methods of arranging pamphlets, leaflets, etc., so as to have them readily accessible resulted in the publishing of a number of articles on the subject in the *Journal of Electricity*, and these have been put into pamphlet form in this booklet. In preparing this matter the author, who is the librarian of the Carnation Milk Products Co., Chicago, has depended upon her own experience in practical work and in teaching the subject at the Riverside Library Service School at Riverside, Cal. The subjects covered include sources and selection of material, filing equipment needed, how information is classified, and the alphabetic subject file.

STORAGE BATTERY MANUAL. By Lucius C. Dunn, Lieutenant-Commander, U. S. Navy. Published by the United States Naval Institute, Annapolis, Maryland, 1921. Cloth, 6⅛ x 9¼ in.; 391 pages; 146 figures; 6 tables.

This book was primarily designed as a textbook for the personnel of the Navy, but can be recommended to any student or operating man in general storage-battery practice. The development and theory of the battery are briefly but clearly treated, but most of the book is given over to a wealth of practical information on storage-battery operation, handling, shipping, receiving, etc., and detail of such minute character as to give the work something of the nature of a handbook. Some of this information is ingeniously presented in tabular form, such as the faults in storage-battery operation, their detection and remedies. One chapter is given over to definitions and nomenclature of parts and can be referred back to, as to a dictionary of storage-battery practice. The text is plentifully illustrated with good cuts, three of which are color plates. Altogether, the subject matter is in unusually lucid, readable and useful form.

ELECTRIC WELDING. By Ethan Viall. Published by McGraw-Hill Book Co., Inc., New York City, 1921. Cloth; 6 x 9 in.; 417 pages; 329 illustrations; 28 tables. Price, $4.

This book is a compilation of material on modern electric-welding procedure, methods and equipment. Not only are the methods and procedure explained, but the machines for doing the work are described and numerous illustrations are given. The book is divided into 17 chapters: Electric welding — historical; arc-welding equipment; different makes of arc-welding sets; training arc welders; carbon-electrode arc welding and cutting; arc-welding procedure; arc-welding terms and symbols; examples of arc-welding jobs; physical properties of arc-fused steel; metallography of arc-fused steel; automatic arc welding; butt-welding machines and work; spot-welding machines and work; welding boiler tubes by the electric-resistance process; electric welding on high-speed steel and stellite in tool manufacture; electric seam welding; making proper rates for electric welding, and the strength of welds. In the arrangement the material has been classified so as not only to make it convenient for reference purposes, but also to enable the reader to compare with ease the different makes and types of apparatus. The scope of the work is such as to make it of interest not only to welding engineers but also to the practical welder, and it should have a wide field of usefulness in the rapidly growing industry it is intended to serve.

NATIONAL ELECTRICAL SAFETY CODE. Third Edition. Handbook No. 3, published by the Department of Commerce, Bureau of Standards, Washington, D. C., 1921. Cloth; 5 x 7½ in.; 366 pages; 45 tables. Price, 40 cents.

This Code supersedes Circular No. 54, and consists of four main parts dealing respectively with (1) the installation and maintenance of electrical supply stations and substations; (2) the installation and maintenance of overhead and underground supply and signal lines; (3) the installation and maintenance of utilization equipment; (4) rules for the operation of equipment and lines; and supplementary sections which include rules for protective grounding of equipment and circuits. The greatest changes are in Part 2. The loading specifications, upon which are based the requirements for strength of construction, have been simplified and applied to signal lines crossing railways, for which arbitrary rules were formerly used. The rules have been rearranged in more convenient order, and an index has been added which greatly facilitates the location of rules on any given item. The sag tables have been extended to cover iron and steel conductors.

The new edition of these rules is in pocket size and has been entirely separated from the discussion of the rules which accompanied them in the second edition. This discussion has been considerably amplified and will be published separately as Handbook No. 4, which is now in press. This handbook will be valuable in interpreting the rules and in making their intent and their justification more plain to the reader. The discussion constitutes a companion volume to the Code itself, which should be secured by all those who have occasion to use the rules.

Copies of Handbook No. 3 may be secured from the Superintendent of Documents, Government Printing Office, Washington, D. C. Remittances should be made by cash or money order.

COMMERCIAL POSSIBILITIES IN AFRICA

The National Foreign Trade Council, 1 Hanover Square, New York Ctiy, has issued a 6 x 9-in., 30-page pamphlet, entitled "Commercial Possibilities of the Union of South Africa," which may be had free of charge from O. K. Davis, secretary of the council. It contains information about market conditions, strategic trade centers, the comparative importance of different industries and other matter that should be helpful to anyone expecting to trade in South Africa. According to this booklet the changes caused by the war have created an excellent opportunity in that country for American manufacturers.

Personals

Ivar Lundgaard, formerly with the Rochester (N. Y.) Gas and Electric Corporation, is now with the Automatic Refrigerating Co., Hartford, Conn.

Frank Burton, an engineer with Donaldson & Myers, has been appointed commissioner of the department of buildings and safety engineering, Detroit, Mich., to succeed John C. McCabe.

Arthur Bielek, previously instructor in mechanical drawing at the University of Maryland, College Park, Md., is now experimental engineer for Warren Webster & Co., Camden, N. J.

H. I. Lewis has left the Bishop & Babcock Co., of Cleveland, Ohio, to become associated with E. A. Burrows, Chicago, Ill., in general consulting and refrigerating engineering. He is also chief engineer for the Illinois Montague Iron Works, of Chicago.

Arthur H. Kohlbusch has resigned as construction superintendent at the Essex Power Station of the Public Service Electric Co., Newark, N. J., to become associated with Payne Dean, Limited, engineers and contractors for electric valve-control equipment, New York City.

J. H. Edwards, of Huntington, W. Va., was elected president of the new West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers at its organization meeting in Huntington recently. W. R. Harler, Ecles, W. Va., is vice president and Herbert Smith, Huntington, W. Va., is secretary.

Society Affairs

The Engineers' Club of Philadelphia will hold its annual meeting May 17.

Birmingham Section, A. S. M. E., is to hold its annual business meeting May 18.

Eastern New York Section, A. S. M. E., will meet May 19 to hear a talk on "Synchronous Motors" by A. R. Stevenson, of the G. E. Co.

Philadelphia Section, A. S. M. E., will hold its annual section dinner May 20 at the Hotel Adelphia roof.

Atlanta Section, A. S. M. E., is to meet May 21 for an address on "Hydro-electric Power Plants" by C. G. Adsit, of the Georgia Railway and Power Co.

The American Water Works Association is to hold its forty-first annual convention June 6-10 at the Hollenden Hotel, Cleveland, Ohio.

The Stoker Manufacturers' Association is to hold its annual meeting May 24-26 at the Red Lion Inn, Stockbridge, Mass. Subjects to be discussed include coal analysis and standard minimum setting heights for boilers.

Miscellaneous News

The Queenston-Chippawa Hydro-Electric Development will surely be ready to deliver power by September, 1921, according to an announcement made recently in the Ontario Legislature by Hon. D. Carmichael, M. P. P. and member of the Hydro-Electric Power Commission of Ontario. He said the total cost was estimated to be about $55,000,000, or, on the basis of 500,000 hp., about $110 per horsepower.

A Good Time was had by all when the newly organized Local 119 of the National Association of Stationary Engineers held its first annual ball April 28 in Jersey City, New Jersey. It was opened and presided over by A. Harry Moore, politically prominent in New Jersey, and it is said that Jack Armour, of *Power* was also seen among those present. The affair as a whole was so successful that it is regarded as a most promising beginning of the new organization's activities.

Trade Commissioner W. H. Rastall, after nearly three years spent in the Far East investigating the markets for American industrial machinery, is returning to this country. Mr. Rastall, a mechanical engineer, has secured much valuable information in the course of this survey. Manufacturers who may be interested in conferring with him may address him through the District Office of the Bureau of Foreign and Domestic Commerce at 307 Customhouse, San Francisco, California.

The Water-Power Measure that has been for some weeks before the New York Legislature has been finally adopted and signed by the governor, so that it is now a law. The bill provides for a commission of five to superintend the leasing of the state's water power in somewhat the same way as under the similar Federal measure. The commission is to grant licenses for the diversion and use of water for periods of fifty years to those applicants whose plans are most favorable to the state.

Business Items

Robert P. Schoenijohn, consulting engineer, has moved his office to the Industrial Trust Bldg., Tenth and Shipley Sts., Wilmington, Del.

The Ross Heater and Manufacturing Co., Inc., Buffalo, N. Y., has opened a branch office at 2 Rector St., New York City, in charge of C. M. Hardin.

The Chicago Fuse Manufacturing Co. has moved its New York office from the crowded downtown section to the more accessible center of the city in the Tilden Building, 105 West 40th St.

The Mesta Machine Co. has announced the removal of its Chicago office from the temporary location in the Railway Exchange Building to permanent quarters in the McCormick Building, Michigan Boulevard.

The Bonnot Co., Canton, Ohio, sole licensees in the United States for Holbeck pulverized-coal systems, has announced that W. J. Lynch, who has been special steel plant representative, is now district manager at Chicago, with offices in the Continental & Commercial Bank Building.

The Oil Specialties and Supply Co., 39 Cortlandt St., New York City, has been appointed Eastern representative for the Flexitallic Gasket Co.

The Uehling Instrument Co., of New York City, has moved its Chicago office to the Great Northern Bldg., 20 West Jackson Boulevard, and has appointed Walter C. Lange as manager of the office.

The Power Specialty Co., manufacturer of Foster superheaters, economizers and oil stills, has opened additional offices at 512 Reliance Bldg., Kansas City, in charge of W. F. Meyer, and 627 Linz Bldg., Dallas, Tex., in charge of M. W. Brown.

The Quigley Furnace Specialties Co., 29 Cortlandt St., New York City, has appointed W. H. Gaylord, Jr., formerly president of the Gaylord International Engineering Construction and later sales manager of the McPhee Cement Co., as assistant traveling sales manager.

Trade Catalogs

The Sprague Electric Works, 527 West 34th St., New York City, is distributing Bulletin 48967, describing electric hoists, cranes and winches.

The Root Co., Bristol, Conn., is sending out an attractive 7 x 10-in. 32-page catalog of Root automatic counters used for keeping track of repetitive operations.

The Griscom-Russell Co., 90 West St., New York City, has issued a new 6 x 9-in. 24-page bulletin, No. 330, on the Reilly self-scaling evaporator as applied to marine service.

Allen General Supplies Limited, 205 Yonge St., Toronto, Canada, has prepared a 6 x 9-in. 24-page composite catalog of fuel-saving and mechanical equipment made by 14 manufacturers.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	April 26 1921	May 3 1921
Pocahontas,	Columbus	$3.35	$3 35
Clearfield,	Boston	2.20	2 00@2.65
Somerset,	Boston	2.80	2 25@3 60
Pittsburgh,	Pittsburgh	2.25	2 25
Kanawha,	Columbus	2 25	2 00
Hocking,	Columbus	2 20	2 00
Pittsburgh No. 8	Cleveland	2 20	2 15@2 25
Franklin, Ill.,	Chicago	3 40	3 35@3 50
Central, Ill.,	Chicago	2 75	2 75@3 15
Ind. 4th vein,	Chicago	2 75	3 00@3 50
Standard,	St. Louis	1 80	1 75@1 85
West Ky.,	Louisville	2 25	2 10
Big Seam,	Birmingham	2.95	2 85@3 10
S. E. Ky.,	Louisville	2.75	2 50@2 85

DIESEL FUEL OIL

New York—On April 26, Port Arthur light oil, 23@25 deg. Baumé, 5¾c. per gal. 30@35 deg., 6½c. per gal. f.o.b. Bayonne, N. J.

Chicago — April 23, for 24@28 deg. Baumé, 70@75c. per bbl.; 32@34 deg., 2¾@3c. per gal. In tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—April 30, prices f.o.b. cars, tank lots: 24@26 deg. Baumée, 70c. per bbl.; 26@28 deg., 75c.; 28@30 deg., 80c.; 32@34 deg., 2¼c. per gal.

Baltimore—On April 23, f.o.b. refinery; in tank-car lots: 24+ deg. Baumé, 6¼c.; 26@28 deg., 6¾c.; 30@34 deg., 7¾c.; 14+ deg., $1.95 per bbl.; 16@20 deg., $1.85 per bbl.

Pittsburgh—On May 2, f.o.b. refinery; Pennsylvania, 36@40 deg., 5c. per gal.; Oklahoma, 24@30 deg., 65c., 32@34 deg., 75c. per bbl.; gas oil, 32@34 deg. 2¼c. per bbl., 36@38 deg., 2¾c. 38@40 deg. 3c.

Philadelphia—On April 12; 26@28 deg. Baumé, Oklahoma, 85c. per bbl; 30@34 deg., Oklahoma (group 3) 3c. per gal.; 16@20 deg., Seaboard, 5c. per gal.

Cincinnati — April 23, for 22@28 deg. Baumé, 7.34c. per gal.

Cleveland — April 23, for 22@28 deg. Baumé, 5½c. per gal.

New Construction

PROPOSED WORK

N. H., Berlin—The School Bldg. Comn. is having plans prepared for a 2 story, school and hall here. About $300,000. T. M. James Co., 3 Park St., Boston, Mass., Archt.

Mass., Cambridge—The city received bids for pumping and filtration apparatus for water purification plant at Fresh Pond, from the Roberts Filter Mfg. Co., 6th and Columbia Sts., Darby, Pa., $225,900; N. Y. Contr. Jewell Filtration Co., East Centre St., Nutley, N. J., $228,000; Norwood Eng. Co., Florence, Mass., $231,600.

Mass., New Bedford—The Hospital Bldg. Comn. plans to build a 3 story hospital on Mt. Pleasant and Myrtle Sts. About $1,000,000. J. S. McIntyre, 22 Clifford Bldg., Archt.

Conn., West Hartford—The School Comn. is having plans revised for a 2 story, 200 x 210 ft. high school and auditorium on Main St. About $500,000. W. F. Marchant, 36 Pearl St., Hartford, Archt.

N. Y., Maspeth, L. I.—The Bd. Educ., 500 Park Ave., New York City, plans to build an addition to P. S. 72 here. About $276,000. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., Mt. Vernon—The Yonkers & Mt. Vernon Ice Corp., 29 South 11th Ave., is having plans prepared for a 100 x 130 ft. ice plant on 13th Ave. and 3rd St. About $100,000. J. Conte, Pres. T. J. Bird, 103 Park Ave., New York City, Engr. Sibley & Featherston, 101 Park Ave., New York City, Archts.

N. Y., New York (Brooklyn Boro)—The Bd. Educ., 500 Park Ave., New York City, plans to build a school, P. S. 187 on 65th St. and 12th Ave., $1,000,000, P. S. 184 on Stone and Newport Aves., $1,000,000, P. S. 67, St. Edwards St., $680,000, P. S. 183 on Saratoga and Riverdale Aves., $1,000,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., New York (Brooklyn Boro)—The Bd. Educ., 500 Park Ave., New York City, is having plans prepared for a school, P. S. 186 on 76th St. and 19th Ave., $1,000,000 and a high school to be known as the Brownsville High School on Pennsylvania Ave. About $1,500,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., New York (Brooklyn Boro)—The Chateau Constr. Co., c/o Shampan & Shampan, Archts. and Engrs., 50 Court St., is having plans prepared for a 6 story, 150 x 150 ft. apartment house including a steam heating system on St. Marks and New York Aves. About $600,000.

N. Y., New York (Bronx Boro)—The Bd. Educ., 500 Park Ave., New York City, received bids for installing heating and ventilating apparatus, etc. in the Annex of P. S. 43 on 136th St. and Brown Pl., from the Raisler Heating Co., $41,500; Gillis & Geoghegan, 537 West Bway., New York City, $44,440; E. Rutzler Co., 404 East 49th St., New York City, $46,820. Noted April 26.

N. Y., New York (Manhattan Boro)—The Amer. Sugar Refining Co., 117 Wall St., is in the market for 600 electric motors.

N. Y., New York (Manhattan Boro)—S. Roseff, 113 West 4th St., Mt. Vernon, is having plans prepared for a 5 story, 67 x 87 ft. apartment house including a steam heating system on Creston Ave. near Burnside Ave., here. About $350,000. Gronenberg & Leuchtag, 303 5th Ave., Archts. and Engrs.

N. Y., Watertown—The Woodruff Holding Co., c/o Woodruff Hotel, will soon receive bids for altering present hotel and building and constructing a 7 story addition including a steam heating system. About $500,000. J. L. Bowling, Mgr. Rich & Mathisius, 320 5th Ave., New York City, Archts. and Engrs.

N. J., Atlantic City—W. O. Roop is having plans prepared for a 3 story, 100 x 200 ft. apartment house including a vapor heating system and refrigerating plant. About $250,000. S. G. Dobbins, 18 South Virginia St., Archt.

N. J., Haddenfield—Remington & Vosbury, Engrs., 6th and Market Sts., Camden, will soon receive bids for a sprinkling system for the greens on the golf course for the Tavistock Country Club, here. A centrifugal electric driven pump will be installed. About $15,000

N. J., Woodstown—The Woodstown Coal & Ice Co. plans to build a 2 story, 20 x 100 ft. addition to its cold storage plant. About $25,000.

Pa., Mayview (Bridgeville P. O.)—The Dept. of Charities of Pittsburgh will soon receive bids for a transmission plant for the new alternating current system to replace the present direct current system at the Pittsburgh City Home and Hospitals, here. About $80 000

Pa., Reading—The Reading Hospital Comn., Front and Spring Sts., is having

plans prepared for a 3 story, 42 x 80 ft. laundry and power plant, here. N. A. Malberg, Flanders Bldg., Philadelphia, Archt. I. H. Francis, Otis Bldg., Philadelphia, Engr.

Pa., Uniontown—The Uniontown Hospital will soon award the contract for a 2 story, 30 x 50 ft. boiler house. About $30,000. Harry Waltman, Archt.

Md., Baltimore—D. C. Elphinstone, 408 Continental Bldg., is in the market for straight line steam driven air compressor, 157 ft., Ingersoll Rand preferred and a 20 or 25 ton electric crane with a 60 in. boiler, Ohio, McMyler or Industrial preferred.

D. C., Washington—J. A. Wetmore, Supervising Archt., Treasury Dept., will receive bids until May 25 for the installation of complete mechanical equipment for the power house at the U. S. Pub. Health Service Sanatorium, here.

N. C., Charlotte—S. L. Williams, Box 962, is in the market for motors or gasoline engines, etc.

N. C., Winston-Salem—The Bd. Educ. will soon award the contract for a 4 story, 160 x 250 ft. high school and art building. About $1,000,000. C. Barton King, 1218 Bailey Bldg., Philadelphia, Pa., Archt. Wiley & Wilson, 907-10 Peoples Natl. Bank Bldg., Lynchburg, Va., Engrs.

Fla., St. Petersburg—The city will receive bids about May 25 for a new electric driven pumping station to replace steam driven plant. Four centrifugal pump units, to have a 1,000 gal. per min. capacity will be installed in same. About $118,000. R. E. Ludwig, City Hall, Engr.

Tenn., Nashville—The Water Dept., plans to expend $425,000 to improve the reservoir and pumping station. Work will include engine foundations, 20 ton electric crane, etc. Chester & Fleming Union Bank Bldg., Pittsburgh, Pa., Consult. Engrs.

Ky., Auxier—The United Block Coal Co. is in the market for coal mining machinery including a boiler for 500 ton capacity mine, generator, etc. W. White, Genl. Mgr.

Ky., Louisville—The Louisville Council of the Knights of Columbus, 816 South 4th St., is having plans prepared for a 2 or 3 story hall on 3rd St. and Bway. About $600,500. J. J. Gaffney, 437 South 2nd St., Archt.

O., Akron—J. E. Eberson, Archt. and Engr., 64 East Van Buren St., Chicago, Ill., will receive bids until May 14 for a 10 story, 130 x 250 ft. hotel and theatre building, for the Commodore Perry Hotel Co. About $3,000,000. Noted March 1.

O., Cleveland—The Bd. Educ. will receive bids May 23 for a 3 story school including a steam heating system on East 102nd St. and Mt. Auburn Ave. About $400,000. W. R. McCormack, East 6th St. and Rockwell Ave., Archt.

O., Cleveland—The Independent Towel & Supply Co., 1822 Central Ave. plans to build a 1 story laundry and boiler house addition. About $50,000. Christian-Schwarzenberg & Garda, 1900 Euclid Ave., Archts.

O., Columbus—C. B. Turner, Supt. of the Columbus Light Plant, is having plans prepared for the installation of new boilers and mechanical stoker at the plant. A bond issue of $110,000 has been authorized for this purpose. Noted Jan. 25.

O., Dayton—Nelson Talbott, Runnymede Rd., plans to build a 5 to 8 story, 200 x 200 ft. family hotel on 1st and Ludlow Sts. About $350,000. Holabird & Roche, 104 South Michigan Ave., Chicago, Ill., Archts.

O., Warren—The Bd. Educ., will receive bids until May 16 for two 2 story, 110 x 220 ft. junior high schools including steam heating systems. About $500,000. R. J. Keish, Western Reserve Bank, Archt.

O., West Park—The Bd. Educ. will receive bids until May 21 for a 2 story, 75 x 216 ft. school including a steam heating system on West 125th St. near Lorain Ave. About $300,000. W. J. Featherstone, Clk. Fulton, Taylor & Cahill, 8120 Euclid Ave., Cleveland, Archts.

O., Youngstown—G. V. Hamory, North Phelps St., plans to build a 6 story, 180 x 200 ft. store and office building on Commerce St. About $850,000. P. Boucherle, Stambaugh Bldg., Archt.

Ind., Elkhart—The Amer. Coating Mills will soon award the contract for a 3 story, 100 x 160 ft. paper mill including a high pressure steam plant on Division St. About $675,000. J. L. Carey, 208 North Laramie Ave., Chicago, Ill., Engr.

Ind., Indianapolis—The city will receive bids until May 25 for the installation of equipment in the pump and screen house unit of the sewage disposal plant at Sellers Farm, here which was ordered by the Bd. of Sanitary Comrs. Equipment includes 1 electrically operated 5 ton power house type crane for 54 ft. 4 in. span fully equipped, three 30 in. and three 24 in. electrically operated, flanged, low pressure gate valves all equipped with motors, etc., three 48 in. and two 36 in. hand operated, bell end, low pressure gate valves, three 30 in. and three 24 in., flanged, balanced, check valves for low pressure and designed for minimum loss of head in operating service, five 48 in. hydraulically operated sluice gates, six 36 in. standard sluice gates, two 60 in. special sluice gates and one 54 in. standard sluice gate, 12 complete screen clarifiers for the purification of sewage, and one 12 in. well, drilled to a depth of approximately 80 ft. with screen and casing in place.

Mich., Detroit—The Carmela Theatre Co., c/o P. Rossello, Archt., 406 Congress Bldg., is having plans prepared for a 2 story theatre and office building on Shoemaker Rd. and Hurlbut Ave. A steam heating system will be installed in same. About $500,000.

Ill., Chicago—A. J. Jordan, 111 West Washington St., plans to build a 5 story, 85 x 175 ft. apartment house including a steam heating system on Drexel Blvd. and 43rd St. About $650,000. W. W. Ahlschager, 65 East Huron St., Archt.

Ill., Chicago—Lubliner & Trinz, 25 East Jackson St., plans to build a 3 story, 266 x 300 ft. theatre and store building on Belmont and Ashland Aves. About $2,000,000.

Ill., Chicago—Philipsborns, 511 South Paulina St., is having plans prepared for an 8 story, 150 x 200 ft. mail order plant including a steam heating system on Harrison and Paulina Sts. About $1,000,000. A. S. Alschuler, 28 East Jackson Blvd., Archt.

Ill., Dahlgren—The city will receive bids about May 15 for a 1 story electric plant addition. About $15,000. Fuller & Beard, Chemical Bldg., St. Louis, Mo., Engrs.

Ill., Rockford—The Petroleum Motor Car Co., 220 South State St., Chicago, will soon award the contract for a 2 story, 270 x 720 ft. factory including a steam heating system. About $2,000,000. R. C. Dale, Mgr. Arnold Co., 105 West Monroe St., Chicago, Archt.

Ill., White Hall—The city c/o H. W. Roodhouse, plans to build a 1 story electric light plant. About $75,000. Architect not yet appointed.

Wis., Milwaukee—The Nash Motors Co., Clement and Oklahoma Aves., is having plans prepared for a 3 story, 100 x 600 ft. auto body and sheet metal plant on Clement Ave. About $500,000.

Wis., Milwaukee—The Safe Amusement Co., 160 5th St., plans to build an 8 story, 150 x 200 ft. theatre and office building on Grand Ave. and 6th St. About $500,000. Architect not yet appointed.

Wis., Platteville—The Bd. of Regents of Normal Schools of Wisconsin, Capitol Bldg., Madison, will receive bids until May 13 for a boiler house for the State Normal school, here.

Wis., Platteville—The Fiedler Motor Co. will soon award the contract for a 2 story, 100 x 136 ft. garage, and office building, including steam heating system and power machinery, on Water and Main Sts. About $75,000. H. Kleirhammer, Archt.

Wis., River Falls—The Bd. of Regents of the Normal Schools of Wisconsin, Capitol Bldg., Madison, will receive bids until May 13 for two 150 hp. Scotch Marine boilers with Hawley furnaces for the State Normal school, here.

Wis., Whitewater—The Bd. of Regents of the Normal Schools of Wisconsin, Capitol Bldg., Madison, will receive bids until May 13 for three 150 hp. Scotch Marine boilers with Hawley furnaces for the State Normal School, here.

Wis., Wonewoc—The Baraboo Valley Utilities Co. plans to extend power line from Elroy to supply Kindad, New Lisbon, and Camp Douglas with power. Cost between $50,000 and $60,000. A. P. Gate, Secy.

Minn., Minneapolis—The Bd. Educ., City Hall, will soon award the contract for a 3 story, 200 x 300 ft. junior high school including a steam heating system on 28th Ave. South and East 41st St. About $600,000. G. F. Womrath, Business Supt. E. H. Enger, 305 City Hall, Archt.

Kan., Lawrence—The state is having plans prepared for a 2 story, 76 x 118 ft. power house at the University, here. About $300,000. J. M. Shea, Kansas University, Engr.

Kan., Lawrence—The University Endowment Association will soon award the contract for a 4 story, 100 x 180 ft. union building including a steam heating system. About $500,000. Goldwin & Goldsmith Archts. C. C. Williams, Engr.

Kan., Wellington—The city is having plans prepared for a 40 x 50 ft. electric plant including a 1000 kva. turbo generator and superheated spray pond equipment. About $60,000. L. A. Walton, Clk. Benham & Mullergren, Firestone Bldg., Kansas City, Mo., Engrs. Noted Oct. 12.

Mont., Miles City—The County is having plans prepared for a steam plant to develop 1,200 hp. and plans to install 2 electric motor driven pumps in connection with the proposed Calabar-Paragon irrigation Dist. About $150,000. H. E. Fearnall, Engr.

Mo., Boonville—W. S. Mitchell plans to build a 2 story tire factory. About $200,000. Architect not yet appointed.

Mo., Unionville—The city plans to build a 1 story, 60 x 70 ft. electric plant. About $84,000. M. Flynn, Supt. Henningson, Natl. Bldg., 12th and Harney Sts., Omaha, Engr.

Okla., Oklahoma City—R. T. Stuart Co., The Oklahoma City Trust Co., and the Mid Continent Insurance Co., 20 West Main St., plans to build a 20 story office building. About $1,000,000.

Col., Denver—The Society of Jesuits plans to build several buildings including a chapel, science hall, two dormitories, stadium and power plant on West 50th Ave. and Lowell Blvd. About $2,000,000. The construction of a dormitory which is to be the first unit will be started this fall. Rev. Father R. M. Kelly, Pres.

Cal., Los Angeles—Phillip, Sartori and Associates 431 H. W. Hellman Bldg., are having preliminary sketches prepared for a 12 story 165 x 360 ft. hotel on 5th and Olive Sts. About $6,000,000.

Cal., Los Angeles—W. W. Paden and Associates, 427 Story Bldg., are having plans prepared for an 11 story, 54 x 130 ft. hotel on 7th and Lucas Sts. About $325,000. L. L. Jones, 468 Pacific Electric Bldg., Archt.

Cal., Los Angeles—The Phillip, Sartori and Associates, 431 H. W. Hellman Bldg., are having preliminary sketches prepared for a 12 story, 165 x 360 ft. hotel on 5th and Olive Sts. About $6,000,000.

Ont., London—E. V. Buchanan, Engr., City Hall, is in the market for a centrifugal waterworks pump to have a daily capacity of $3,000,000 gal., for the Utilities Bd.

Ont., Paisley—The City Council, c/o Reeve Forrester, 190 University Ave., Toronto, plans to take over and rebuild the plant of the Paisley Electric Co. and extend lines. Noted April 19.

Sask., Yorkton—The Saskatchewan Co-operative Creameries Ltd., Regina, plans to build a creamery and cold storage plant, here. About $75,000.

Sask., Weyburn—The Saskatchewan Co-operative Creameries, Regina, plans to build a creamery and cold storage plant, here. About $60,000.

CONTRACTS AWARDED

Mass., Northampton—The Northampton Electric Lighting Co., 189 Main St., has awarded the contract for an electric light building a 2,300 volt and 8 panel switchboard system, to the Westinghouse Electric & Mfg. Co., 6905 Susquehanna St., Pittsburgh, Pa.

N. Y., New York (Manhattan Boro)—The Bd. of Purchases has awarded the contract for furnishing boilers and condenser tubes, etc., to the Amer. Brass Co., 195 Bway., at $6,944. Noted Jan. 11.

N. Y., Wende (Millgrove P. O.)—The Bd. of Supervisors, City Hall, has awarded the contract for installing a steam heating system in the proposed penitentiary, to the Power Efficiency Corp., White Bldg., Buffalo, at $24,968. Noted April 5.

Pa., Conemaugh—The School Dist., 237 Main St., has awarded the contract for the installation of a heating and ventilating system, to the Cambria Plumbing & Heating Co., Johnstown, at $22,214.

D. C., Washington—The Dist. Comrs. have awarded the contract for the substructure of power house at the Gallinger Hospital to G. E. Wyne, Home Life Bldg., at $149,700.

O., Cleveland—The city has awarded the contract for installing a refrigerating system in the new city hospital buildings, to the Hibbard Co., Chicago, Ill., at $40,245. Noted April 26.

Mich., Green Lake (R. D. Caledonia)—The Aviation Country Club, 309 F. P. Bldg., has awarded the contract for furnishing labor and material for a water system to include a 500 gal. per min. electrically driven fire pump., to Ray D. Baker, 1631 Elmhurst Ave., Detroit, at $25,000.